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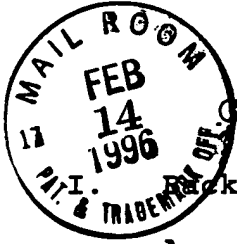
SPECIFICATION

To all whom it may concern:

Be it known that Tony M. Pearce, a citizen of the United States of America, has invented a new and useful invention entitled "GELATINOUS CUSHIONS WITH BUCKLING COLUMNS" of which the following comprises a complete specification.

12/0

A/NOTEE



GELATINOUS CUSHIONS WITH BUCKLING COLUMNS

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Background of the Invention

A. Field of the Invention

This invention relates to the field of cushions. More particularly, this invention relates to a cushion made of gelatinous elastomer or gelatinous viscoelastomer which has hollow columns that compress to provide cushioning and which buckle to relieve pressure peaks.

B. The Background Art

In the prior art, there have been numerous attempts to provide a cushion which achieves comfort by eliminating peak pressure areas and by evenly distributing the cushioning force over a broad surface area. The relevant prior art which the inventor is aware of is categorized and summarized below.

1. Foam Cushions: Foam cushions typically include open cell polyurethane foam because of its low cost and light weight. The open cells are in effect air bubbles within the polyurethane which can be compressed and from which air can escape when a force, such as the weight of a cushioned object, is placed on the foam. Alternatively, foam cushions may use closed cell foam, in which the cells contain air or another gas, but the cells are closed so that the air or gas cannot escape even when a compressive force is applied to the foam. Closed cell cushions tend to resist deformation more than similarly constructed open cell cushions. In function, foam cushions behave much the same as a spring, permitting the cushioned object to sink into the foam and to be supported by rebound pressure; the more the

1 cushioned object sinks into the foam, the higher the rebound
2 pressure. When the cushioned object is removed, the foam has a
3 tendency to return to its original shape, a characteristic
4 referred to as "shape memory." A significant problem with foam
5 cushions is that protruding portions of the object being
6 cushioned are placed under the highest pressure due to the foam's
7 spring-like behavior, resulting in pressure on the cushioned
8 object not being equalized. Closed cell foam cushions created
9 even worse pressure peaks than open cell foam cushions due to
10 their inability to permit gas to escape from their cells when the
11 cushion is called on to support an object.

12 Examples of cushions that include foam are included in the
13 following documents: United States Patent No. 4,713,854 issued
14 in the name of Graebe on December 22, 1987; United States Patent
15 No. 4,709,431 issued in the name of Shaktman on December 1, 1987;
16 United States Patent No. 4,628,557 issued in the name of Murphy
17 on December 16, 1986; United States Patent No. 4,467,053 issued
18 in the name of Markle on August 21, 1984; United States Patent
19 No. 3,518,786 issued in the name of Holtvoigt on July 7, 1970;
20 and United States Patent No. 5,335,907 issued in the name of
21 Spector on August 9, 1994, each of which is hereby incorporated
22 in its entirety for the material disclosed therein. The
23 following patents include both foam and a gel or fluid (see
24 discussion of gels below): United States Patent No. 4,952,539
25 issued in the name of Hanson on August 29, 1990; United States
26 Patent No. 5,147,685 issued in the name of Hanson on September
27 15, 1992; United States Patent No. 5,058,291 issued in the name
28 of Hanson on October 22, 1991; United States Patent No. 5,255,404

1 issued in the name of Dinsmoor, III et al. on October 26, 1993;
2 United States Patent No. 5,201,780 issued in the name of
3 Dinsmoor, III et al. on April 13, 1993; United States Patent No.
4 4,842,330 issued in the name of Jay on June 27, 1989; and United
5 States Patent No. 4,726,624 issued in the name of Jay on February
6 23, 1988, each of which is hereby incorporated in its entirety
7 for the material disclosed therein.

8 2. Fluid Cushions: Some in the prior art have
9 attempted to design a comfortable cushion using some type of a
10 flowable fluid (such as liquid, air, gas, emulsion, lubricated
11 objects or particles, etc.) within one or more fluid-tight
12 bladders. When an object is placed on the fluid cushion, or when
13 an object resting on the cushion is re-positioned, the fluid
14 flows within the bladder and the bladder correspondingly deforms
15 to conform to the shape of the object being cushioned. This
16 results in a cushion which tends to equally distribute a
17 cushioning pressure across the entire contact surface of the
18 object being cushioned, and maximizes the percentage of the
19 surface area of the object which is under pressure.
20 Correspondingly, this also eliminates or reduces pressure peaks
21 on the cushioned object.

22 Prior art fluid cushions have a number of problems, however.
23 First, when the object being cushioned is shifted or repositioned
24 on the fluid cushion, instability may result. Second, depending
25 upon the type of fluid used, the cushion may have a high thermal
26 mass and a high rate of thermal transfer, resulting in a cushion
27 which is cold to the touch and which tends to draw heat out of
28 the object being cushioned. This can result in discomfort when

1 the object being cushioned is a human being. Third, fluid
2 cushions are typically very costly to manufacture. Fourth, due
3 to the necessity of maintaining a fluid-tight bladder, fluid
4 cushions may be unreliable due to the possibility of bladder
5 puncture. Fifth, if a fluid cushion is not of sufficient
6 thickness, the object being cushioned may displace enough of the
7 cushioning fluid to bottom out against a base on which the fluid
8 bladder is resting, resulting in little or no cushioning effect.
9 Sixth, fluid cushions have little shape memory, so they do not
10 return to their original shape when the cushioned object is
11 removed. Consequently, fluid cushions do not have an
12 aesthetically pleasing appearance and are typically not
13 considered appropriate for furniture. Seventh, fluid cushions
14 typically do not permit good air circulation between the
15 cushioned object and the cushion, resulting in moisture building
16 up between the cushioned object and the bladder (e.g.
17 perspiration from a human body). And eighth, many (but not all)
18 prior art fluid cushions tended to be very heavy. Fluid cushions
19 which use the composite mixture disclosed in United States Patent
20 No. 5,421,874 tend to be lightweight, however.

21 Examples of fluid cushions include the following: United
22 Kingdom Patent No. 1,261,475 which was published on January 26,
23 1972; United States Patent No. 5,369,828 issued in the name of
24 Graebe on December 6, 1994; United States Patent No. 5,103,518
25 issued in the name of Gilroy et al. on April 14, 1992; United
26 States Patent No. 4,945,588 issued in the name of Cassidy et al.
27 on August 7, 1990; United States Patent No. 4,737,998 issued in
28 the name of Johnson, Sr. on April 19, 1988; United States Patent

1 No. 4,485,505 issued in the name of Paul on December 4, 1984;
2 United States Patent No. 4,292,701 issued in the name of Woychick
3 on October 6, 1981; United States Patent No. 3,462,778 issued in
4 the name of Whitney on August 26, 1969; United States Patent No.
5 2,672,183 issued in the name of Forsyth on March 16, 1954; United
6 States Patent No. 2,814,053 issued in the name of Sevcik on
7 November 26, 1957; United States Patent No. 2,491,557 issued in
8 the name of Goolsbee on December 20, 1949; United States Patent
9 No. 5,100,712 issued in the name of Drew et al. on March 31,
10 1992; United States Patent No. 5,255,404 issued in the name of
11 Dinsmoor, III et al. on October 26, 1994; United States Patent
12 No. 5,204,154 issued in the name of Drew et al. on April 20,
13 1993; United States Patent No. 5,201,780 issued in the name of
14 Dinsmoor, III et al. on April 13, 1993; United States Patent No.
15 5,147,685 issued in the name of Hanson on September 15, 1992;
16 United States Patent No. 5,058,291 issued in the name of Hanson
17 on October 22, 1991; United States Patent No. 5,020,176 issued in
18 the name of Dotson on June 4, 1991; United States Patent No.
19 5,018,790 issued in the name of Jay on May 28, 1991; United
20 States Patent No. 5,093,138 issued in the name of Drew et al. on
21 March 3, 1992; United States Patent No. 4,842,330 issued in the
22 name of Jay on June 27, 1989; United States Patent No. 4,761,843
23 issued in the name of Jay on August 9, 1988; United States Patent
24 No. 4,728,551 issued in the name of Jay on March 1, 1988; United
25 States Patent No. 4,726,624 issued in the name of Jay on February
26 23, 1988; United States Patent No. 4,660,238 issued in the name
27 of Jay on April 28, 1987; United States Patent No. 4,588,229
28 issued in the name of Jay on May 13, 1986; United States Patent

No. 4,483,029 issued in the name of Paul on November 20, 1984; United States Patent No. 4,255,202 issued in the name of Swan, Jr. on March 10, 1981; United States Patent No. 4,247,963 issued in the name of Reddi on February 3, 1981; United States Patent No. 4,243,754 issued in the name of Swan, Jr. on January 6, 1981; United States Patent No. 4,229,546 issued in the name of Swan, Jr. on October 21, 1980; United States Patent No. 4,144,658 issued in the name of Swan, Jr. on March 20, 1979; United States Patent No. 4,083,127 issued in the name of Hanson on April 11, 1978; United States Patent No. 4,038,762 issued in the name of Swan, Jr. on August 2, 1977; United States Patent No. 3,968,213 issued in the name of Lynch on October 19, 1976; and United States Patent No. 3,748,669 issued in the name of Warner on July 31, 1973, each of which is hereby incorporated by reference in its entirety for the material disclosed therein.

3. Gel Cushions: Another design which those in the prior art attempted to employ to create an effective cushion included the use of gelatinous materials ("gels"). Gelatinous materials are soft elastic or viscoelastic materials which easily deform but return to their original shape after the deforming force is removed. The prior art gel cushions had one or more of the following problems. First, gel cushions had a high thermal mass and a high coefficient of thermal transfer, making them cold to the touch and causing them to drain heat out of a cushioned object. Second, gel cushions tended to be costly to manufacture. Third, gel cushions had limited compressibility and therefore did not permit the cushioned object to sink deep into the gel. As a result, only a small surface area of the cushioned object is

1 cushioned by a prior art gel cushion, resulting in a greater
2 supporting force being applied on that small surface area than
3 would be applied if a greater surface area of the cushioned
4 object were to contact the gel cushion for support. This is
5 because in order for the cushioned object to sink into prior art
6 gel cushions, the cushions, which tended to be relatively
7 incompressible, must expand in directions generally normal to the
8 direction of the intended sinking, a behavior which cannot be
9 accommodated in most cushioning applications.

10 Notwithstanding their problems in the prior art, gel
11 cushions have some attractive features. For example, a gel
12 cushion permits a near-hydrostatic pressure distribution across
13 the surface area of the cushioned object if the cushioned object
14 is allowed to sink into the gel and the overall dimensions of the
15 cushion are not restricted so that such sinking in would be
16 prevented. Also, gel cushions have the aesthetic advantage,
17 through their shape memory, of being capable of returning to
18 their original shape after the cushioned object is removed.

19 Documents which disclose gel cushions include: United States
20 Patent No. 5,456,072 issued in the name of Stern on October 10,
21 1995; United States Patent No. 5,362,834 issued in the name of
22 Schapel et al. on November 8, 1994; United States Patent No.
23 5,334,646 issued in the name of Chen on August 2, 1994; United
24 States Patent No. 5,191,752 issued in the name of Murphy on March
25 9, 1993; and United States Patent No. 4,913,755 issued in the
26 name of Grim on April 3, 1990, each of which is hereby
27 incorporated by reference in its entirety.

1 4. Thermoplastic Film Honeycomb Cushions: Another
2 type of cushion in the prior art is made from multiple perforated
3 sheets of pliable thermoplastic film which are intermittently
4 welded together and then expanded into a pliable plastic
5 honeycomb. Honeycomb cushions may have problems such as a high
6 cost of manufacture and an inability to equalize supporting
7 pressure in order to avoid pressure peaks on the most protruding
8 parts of the object being cushioned. This is because of the
9 relatively rigid nature of the thermoplastic and thermoplastic
10 elastomer films used in the honeycomb cushion construction.
11 Honeycomb cushions also carry the risk that the cushioned object
12 will bottom out through the cushion. This is because the films
13 are thin and relatively rigid, so collapsed cells within the
14 cushion offer no real cushioning effect.

15 The advantages of honeycomb cushions include their light
16 weight. Most of the cushion consists of voids within the cells
17 of the honeycomb, the voids being filled with air, resulting in a
18 lightweight cushion. Another advantage is that honeycomb
19 cushions provide good air circulation between the cushioned
20 object and the cushion due to the perforations in the cell walls
21 of the honeycomb and/or in the facing sheets above and below the
22 honeycomb cells.

23 Examples of honeycomb or multilayer film cushions are as
24 follows: United States Patent No. 5,445,861 issued in the name
25 of Newton et al. on August 29, 1995; United States Patent No.
26 5,444,881 issued in the name of Landi et al. on August 29, 1995;
27 United States Patent No. 5,289,878 issued in the name of Landi on
28 March 1, 1994; United States Patent No. 5,203,607 issued in the

1 name of Landi on April 20, 1993; United States Patent No.
2 5,180,619 issued in the name of Landi et al. on January 19, 1993;
3 United States Patent No. 5,015,313 issued in the name of Drew et
4 al. on May 14, 1991; United States Patent No. 5,010,608 issued in
5 the name of Barnett et al. on April 30, 1991; United States
6 Patent No. 4,959,059 issued in the name of Eilender et al. on
7 September 25, 1990; and United States Patent No. 4,485,568 issued
8 in the name of Landi et al. on December 4, 1984, each of which is
9 hereby incorporated by reference in its entirety.

10 5. Mattressing: In the prior art there has been work
11 in the field of mattressing, which is considered to be related
12 background against which the invention was made. For references
13 with disclosure relevant to mattressing, the reader is directed
14 to United Kingdom Patent No. 1,261,475 which was published on
15 January 26, 1972; United States Patent No. 5,369,828 issued in
16 the name of Graebe on December 6, 1994; United States Patent No.
17 5,103,518 issued in the name of Gilroy et al. on April 14, 1992;
18 United States Patent No. 4,945,588 issued in the name of Cassidy
19 et al. on August 7, 1990; United States Patent No. 4,737,998
20 issued in the name of Johnson, Sr. on April 19, 1988; United
21 States Patent No. 4,485,505 issued in the name of Paul on
22 December 4, 1984; United States Patent No. 4,292,701 issued in
23 the name of Woychick on October 6, 1981; United States Patent No.
24 3,462,778 issued in the name of Whitney on August 26, 1969;
25 United States Patent No. 2,672,183 issued in the name of Forsyth
26 on March 16, 1954; United States Patent No. 2,814,053 issued in
27 the name of Sevcik on November 26, 1957; and United States Patent

No. 2,491,557 issued in the name of Goolsbee on December 20, 1949, each of which is hereby incorporated by reference.

The reader will find that the prior art thus had numerous shortcomings which are addressed by the invented cushion, as outlined below.

II. Summary of the Invention

It is an object of the invention to provide a cushion that distributes supporting pressure on an object being cushioned in a manner that is generally even and without pressure peaks. It is a feature of the invention that the cushion has a low surface tension and permits a cushioned object to sink deeply into it. This action is due to compressibility of the cushion. It is also a feature of the invented cushion that some of the columns present in the invented cushion tend to buckle under the weight of the object being cushioned. This buckling is especially useful in accommodating protrusions from the object being cushioned into the cushion. The ability to accomodate protrusions through buckling of the cushion columns eliminates pressure peaks. It is a consequent advantage of the invention that the invented cushion is comfortable and does not tend to constrict blood flow in the tissue of a human being on the cushion, thus being suitable for medical applications and other applications where the object being cushioned may be immobile for long periods of time, such as in automobile seats, furniture, mattresses, and other applications.

It is an object of the invention to provide a cushion that eliminates pressure peaks on an object being cushioned. It is a feature of the invention, as mentioned above, that the invented

1 cushion includes columns which buckle under protuberances on a
2 cushioned object. As a result, the cushioned object is not
3 exposed to pressure peaks.

4 It is an object of the invention to maximize the surface
5 area of the cushioned object that is in contact with the cushion
6 by permitting the cushioned object to sink deeply into the
7 cushion, without the prior art problem that exterior surfaces of
8 the cushion that are not in the plane in contact with the
9 cushioned object must expand. It is a feature of the invented
10 cushion that the cushion is compressible and that the cushion
11 includes columns within it that can buckle under the weight of
12 the cushioned object. The bottom of the cushion and its outside
13 periphery, not including the surface of the cushion in contact
14 with the cushioned object, may, if desired, be restrained, but
15 the compressibility and bucklability of the cushion will still
16 permit the cushioned object to sink into the cushion. It is an
17 advantage of the invention that a gel cushion is provided which
18 can have a constrained periphery but which will still permit a
19 cushioned object to sink deeply into it.

20 It is an object of the invention to provide a cushion that
21 eliminates the head pressure found in some fluid cushions. In
22 fluid cushions, the flowable media may be drawn by gravity so
23 that it exerts pressure on some portions of the cushioned object
24 as the cushioning media attempts to flow in response to the
25 gravitational force. This pressure is referred to as "head
26 pressure." Head pressure can cause discomfort and tissue damage
27 to a human using the cushion. The gel of which the invented

1 cushion is made does not flow so it does not develop head
2 pressure.

3 It an object of the invention to provide a cushion which is
4 inexpensive to manufacture compared to prior art cushions. It is
5 a feature of the invention that the invented cushion may be very
6 quickly and cheaply injection molded or cast from suitable low
7 cost gel materials. It is an advantage of the invention that a
8 cushion which incorporates the features of the invention may be
9 produced for substantially less cost than prior art cushions with
10 comparable performance characteristics.

11 It is an object of the invention to provide a cushion that
12 is stable as the center of gravity of the cushioned object is
13 shifted. It is a feature of the invention that a cushioned
14 object may sink deeply into the cushion. It is also a feature of
15 the invention that the gel of the invented cushion does not allow
16 flow of the cushioning media as in fluid cushions. It is also a
17 feature of the invented cushion that it is adapted to accomodate
18 the sinking in of an object but tends to be relatively rigid in a
19 horizontal direction and thus resist horizontal displacing
20 forces. Consequently, an object being cushioned by the invented
21 cushion can be shifted on the cushion without a tendency of the
22 cushion to move unpredictably underneath the cushioned object.
23 As a result, the invented cushion displays a high degree of
24 stability.

25 It is an object of the invention to provide a cushion that
26 will not lose its structural integrity or cushioning effect if
27 punctured. It is a feature of one preferred embodiment of the
28 invention that the gel used to make the cushion is a solid

(although a flexible, resilient solid) at ordinary room temperatures (i.e. below 130° Fahrenheit). Thus, even if the cushion is punctured, there is no escape of cushioning media, as would occur if a prior art fluid cushion were punctured. It is thus an advantage of the invention that superior durability is provided in the cushion.

It is an object of the invention to provide a cushion that has shape memory. It is a feature of the invented cushion that a gel is used to make the cushion that tends to return to its original shape after a displacing force (such as the gravitational force exerted on a cushioned object) is removed. It is an advantage of the invention that attractive cushions suitable for devices such as furniture, automobile seats, theatre seats, etc. are provided. Prior art fluid cushions were not desirable for such applications because they tended to retain the shape of the cushioned object after the cushioned object was removed. This was considered unsightly. The invented cushion, in contrast, returns to its original, as-new shape after the cushioned object is removed.

It is an object of the invention to provide a cushion which provides a superior amount of air circulation between the cushion and the cushioned object in comparison to the prior art. It is a feature of the invention that hollow columns are provided in one preferred embodiment of the invention through which air may circulate. The surface area of the cushioned object that is in contact with the cushion is therefore in contact only with the circumferential rims of the hollow columns. Thus, most of the surface area of the cushioned object within the perimeter of the

1 outermost points of contact between the cushioned object and the
2 cushion is exposed to air circulation through the hollow columns.
3 It is thus an advantage of this structure that heat buildup
4 between the cushioned object and the cushion is lessened in
5 comparison with the prior art cushions. If the cushioned object
6 is a human being, this structure provides the human being with
7 far greater comfort than prior art cushions because the invented
8 cushion will facilitate rapid evaporation of sweat rather than
9 causing a sweat buildup as in prior art cushions.

10 It is an object of the invention to provide a cushion that
11 is lightweight. This is an important object for all applications
12 of the invention, but particularly important for medical
13 applications. It is a feature of the invention that the invented
14 cushion includes a number of hollow columns so that the
15 predominant volume of space occupied by the cushion is actually
16 occupied by a gas such as air. Consequently, the total weight of
17 the cushion is low.

18 It is an object of the invention to provide a cushion that
19 has a low rate of thermal transfer and a low thermal mass. Many
20 prior art cushions, such as fluid cushions, felt cold to the
21 touch and tended to draw heat out of a human being resting on the
22 cushion. This caused discomfort to the human being. The
23 invented cushion occupies a volume of space predominantly with a
24 gas such as air which has a low thermal mass. It is an advantage
25 of the invention that the cushion has a substantially reduced
26 tendency to feel cold to the touch, compared to the prior art,
27 and that the cushion does not tend to draw heat from the object
28 being cushioned. The result is a comfortable cushion.

1 It is an object of the invention to provide a cushion that
2 will offer cushioning protection to a cushioned object even if
3 the cushioned object has bottomed out within the cushion. A
4 cushioned object is considered to have bottomed out within a
5 cushion if it has sunk into the cushion beyond the point where
6 the normal cushioning mechanism is effective. An alternative way
7 of stating this is that the cushioned object has sunk into the
8 cushion to the extent that a portion of the cushion has been
9 compressed to an extent that is not further compressible. The
10 invented cushion, due to the elastic nature of the gel used,
11 tends to have more give and resiliency than a hard surface, such
12 as a wooden chair, would, even when the cushioned object has
13 bottomed out in the cushion. Thus, the cushion continues to
14 provide some cushioning effect beneath the portion of the
15 cushioned object that has bottomed out. Additionally, the
16 cushion will continue to cushion effectively beneath the portion
17 of the cushioned object that has not bottomed out within the
18 cushion.

19 It is an object of the invention to provide a cushion that
20 has a great range of compressibility. The invented cushion, in
21 its preferred embodiments, has a substantial depth measurement
22 along its vertical columns. The cushioned object sinks into the
23 cushion some portion of that depth measurement. The preferred
24 cushion has enough depth and compressibility that the cushioned
25 object can be of a very wide range of weights and still receive
26 effective cushioning from the invented cushion.

27 It is an object of the invention to provide a cushion that
28 achieves near hydrostatic pressure distribution across the

1 contact area of the object being cushioned. The compressibility
2 of the gel columns provides good overall cushioning, and the
3 buckling of columns beneath the most protruding points relieves
4 pressure at the points where it is highest in prior art foam or
5 solid gel cushions.

6 These and other objects, features and advantages of the
7 invention will become apparent to persons of ordinary skill in
8 the art upon reading the specification in conjunction with the
9 accompanying drawings.

10 **III. Brief Description of the Drawings**

11 Figure 1 depicts the invented cushion as part of an office
12 chair.

13 Figure 2 depicts the invented cushion including its
14 cushioning element and cover.

15 Figure 3 depicts a cutaway of the invented cushion of Figure
16 1 at 3-3.

17 Figure 4 depicts a mold which may be used to manufacture the
18 invented cushion.

19 Figure 5 depicts an alternative mold for manufacturing the
20 invented cushion.

21 Figure 6 depicts a cross sectional view of a cushion
22 manufactured using the mold of Figure 5.

23 Figure 7 depicts an isometric view of an alternative
24 embodiment of the invented cushion.

25 Figure 8 depicts a top view of an alternative embodiment of
26 the invented cushion.

27 Figure 9 depicts an isometric view of an alternative
28 embodiment of the invented cushion.

Figure 10 depicts a top view of an alternative embodiment of the invented cushion.

Figure 11 depicts a cross sectional view of a column of the invention during one mode of buckling.

Figure 12 depicts a cross sectional view of a column of the invention during another mode of buckling.

Figure 13 depicts forces in play as a column buckles.

Figure 14 depicts an alternative structure for a column and its walls.

Figure 15 depicts a cross section of a cushion using alternating stepped columns.

Figure 16 depicts an alternative embodiment of the invented cushioning element having gas bubbles within the cushioning media.

Figure 17 depicts a cushion of the invention in use with a combination base and container.

Figure 18 depicts a cushion of the invention having side wall reinforcements to support the cushioning element.

Figure 19 depicts a cushioning element of the invention having a girdle or strap about its periphery to support the cushioning element.

Figure 20 depicts a cushioning element of the invention with closed column tops and bottoms and fluid cushioning media contained within the column interiors.

Figure 21 depicts a cushioning element of the invention with firmness protrusions placed within the column interiors.

1 IV. Description of the Preferred Embodiment

2 A. Configuration of the Cushions

3 Figure 1 depicts a cushioned object 101, in this instance a
4 human being, atop of a piece of furniture 102, in this instance a
5 chair, which includes the invented cushion 103. Although in this
6 embodiment, the invented cushion 103 is depicted as part of an
7 office chair, the invented cushion may be used with many types of
8 products, including furniture such as sofas, love seats, kitchen
9 chairs, mattresses, lawn furniture, automobile seats, theatre
10 seats, padding found beneath carpet, padded walls for isolation
11 rooms, padding for exercise equipment, wheelchair cushions, bed
12 mattresses, and others.

13 Referring to Figure 2, the cushion 103 of Figure 1 is
14 depicted in greater detail. The cushion 103 includes a cover
15 204. The preferred cover is a durable and attractive fabric,
16 such as nylon, cotton, fleece, synthetic polyester or another
17 suitable material which is preferably stretchable and elastic and
18 which readily permits the flow of air through it to enhance
19 ventilation of a cushioned object. Within the cover 204, a
20 cushioning element 205 is to be found. As can be seen from the
21 figure, the cushioning element 205 comprises a cushioning media
22 of a desired shape. In the embodiment depicted, the cushioning
23 element 205 includes gel cushioning media formed generally into a
24 rectangle with four sides, a top and a bottom, with the top and
25 bottom being oriented toward the top and bottom of the page,
26 respectively. The cushioning element has within its structure a
27 plurality of hollow columns 206. As depicted, the hollow columns
28 206 contain only air. The hollow columns 206 are open to the

1 atmosphere and therefore readily permit air circulation through
2 them, through the cover 204 fabric, and to the cushioned object.
3 The columns 206 have column walls 207 which in the embodiment
4 depicted are hexagonal in configuration. It is preferred that
5 the total volume of the cushioning element will be occupied by
6 not more than about 50% gel cushioning media, and that the rest
7 of the volume of the cushioning element will be gas or air. This
8 yields a lightweight cushion with a low overall rate of thermal
9 transfer and a low overall thermal mass. It is not necessary
10 that this percentage be complied with in every instance that the
11 inventive concept is practiced, however.

12 Referring to Figure 3, a cushioned object 101 (in this
13 instance a human being) is depicted being cushioned by the
14 invented cushion 103 which includes cushioning element 205 within
15 cover 204. Also visible is a cushion base 301 of a rigid
16 material such as wood, metal, plastic on which the cushioning
17 element 205 rests. The cushioning element 206 includes hollow
18 columns 206 with walls 207. It can be seen that beneath the most
19 protruding portion of the cushioned object, in this instance a
20 hip bone 302, the hollow columns 303 have walls 304 which have
21 partially or completely buckled in order to accomodate the
22 protuberance 302 and avoid creating a high pressure point below
23 the protuberance 302 in response to the compressive force exerted
24 by the cushioned object. ^{buckled}~~Buckled~~ columns offer little resistance AL
25 to deformation, thus removing pressure from the hip bone area.
26 It can also be seen that in portions of the cushioning element
27 205 which are not under the protuberance 302, the cushioning
28 media which forms the walls 304 of the hollow columns 303 has

1 compressed but the columns 303 have not buckled, thus loading the
2 cushioned object across the broad surface area of its non-
3 protruding portions. From this figure it can be seen the the
4 cushion is yieldable as a result of the compressability of the
5 cushioning media and the bucklability of the columns (or column
6 walls). The cushion 103 is depicted as having been manufactured
7 using the mold depicted in Figure 4. It can be seen from this
8 cushion's response to a compressive force exerted by the
9 cushioned object that the cushion and the cushioning element are
10 adapted to have a cushioned object place on top of them.

11 Referring to Figure 6, a cross section of an alternative
12 embodiment of the invention is depicted. The cushioning element
13 601 includes cushioning media ⁶⁰⁹~~604~~ (which is preferred to be a gel
14 cushioning media) which form walls 605 for columns 602, 603. It
15 can be seen that the columns 602 and 603 are oriented into a
16 group protruding from the top of the cushioning element 601 down
17 into the cushioning media ⁶⁰⁹~~604~~ but not reaching the bottom of the
18 cushioning element of which column 602 is a member, and a group
19 protruding from the bottom of the cushioning element 601 into the
20 cushioning element 601 but not reaching the top of the cushioning
21 element 601 of which column 602 is a member. This yields a
22 generally firmer cushion than that shown in some other figures.
23 This cushion would be manufactured by the mold depicted in Figure
24 5.

25 Referring to Figure 7, an alternative embodiment of a
26 cushioning element 701 is depicted. The cushioning element
27 includes cushioning media 702, columns 703 and column walls 704.
28 The columns depicted in Figure 7 are square in a cross section

1 taken orthogonal to their longitudinal axis, in contrast to the
2 columns of Figure 2 which are hexagonal in a cross section taken
3 orthogonal to their longitudinal axis. It is also of note that
4 in Figure 7, the columns 703 are arranged as an $n \times m$ matrix with
5 each row and each column of columns in the matrix being aligned
6 perfectly adjacent to its neighbor, with no offsetting.

7 Exemplary sizing and spacing of columns in the invention would
8 include columns which have a cross sectional diameter taken
9 orthogonal to the longitudinal axis of about 0.9 inches and a
10 column wall thickness of about 0.1 inches at the thinnest point
11 on a column wall. Many other dimensions and spacing of columns
12 and column walls may be employed while practicing the inventive
13 concept.

14 Referring to Figure 8, a top view of an alternative
15 cushioning element 801 is depicted. The cushioning element 801
16 includes cushioning media 802 which forms column walls 804,
17 columns 803 and an exterior cushioning element periphery 805. It
18 can be seen that the columns 803 of Figure 8 are arranged in
19 offset fashion with respect to some of the columns to which they
20 are adjacent. A myriad of column arrangements is possible from
21 the well-organized arrangements of the columns to a random
22 arrangement. It is preferred that the columns be arranged so
23 that the total volume of gel cushioning media 802 within the
24 volume of space occupied by the cushioning element 801 is
25 minimized. This results in a lightweight cushion. To that end,
26 the columns 803 may be arranged in close proximity to each other
27 in order to minimize the thickness of the column walls 804. This
28 will result in a lighter cushion and a cushion that will yield to

1 a greater extent under a cushioned object of a given weight than
2 a similar cushion with thicker column walls 804.

3 Referring to Figure 9, an alternative cushioning element 901
4 is depicted with cushioning media 902, columns 903, column walls
5 904 and outer periphery 905 of the cushioning element 901 being
6 shown. The columns 902 depicted are round in a cross section
7 taken orthogonal to their longitudinal axes. The reader should
8 note that it may be desirable to include a container or side
9 walls which will contain the outer periphery 905 of the
10 cushioning element. For example, in Figure 9, a rectangular box
11 with interior dimensions just slightly larger than the exterior
12 dimensions of the cushioning element 901 could be employed. Or
13 in Figure 1, the side walls of the cover 204 could be rigid, such
14 as by the use of plastic inserts. The effect of rigid side walls
15 or a rigid container for a cushioning element is that when a
16 cushioned object is placed on the cushioning element, the
17 cushioning media will not be permitted to bulge outward at the
18 cushioning element outer periphery. By preventing such outward
19 bulging, greater cushion stability is achieved and a more direct
20 (i.e. in a direction parallel to the longitudinal axis of a
21 column, which in most of the figures, such as Figure 3, is
22 assumed to be in the direction of the Earth's gravity but which
23 may not always be so) movement or descent of the cushioned object
24 into the cushion is achieved. A direct movement or descent of a
25 cushioned object into the cushion (i.e. parallel to the
26 longitudinal axes of the columns) is desired because the column
27 walls are configured to absorb weight and cushion the cushioned
28 object, or, if the load under a protuberance gets high enough, by

1 buckling of the columns. If a cushioned object travels a
2 substantial distance sideways in the cushion, the hollow portion
3 of the columns may be eliminated by opposing column walls
4 collapsing to meet each other rather than either substantially
5 compressing the cushioning media or by buckling as depicted in
6 Figures 13 and 14. This would not provide the desired cushioning
7 effect as it would result in collapsed columns within the cushion
8 (rather than buckled columns), and the cushion would have little
9 more cushioning effect than a solid block of the cushioning media
10 without the columns.

11 Referring to Figure 10, an alternative embodiment of the
12 invented cushion 1001 is depicted. The cushion 1001 includes gel
13 cushioning media 1002 in the form of an outer cushion periphery
14 1003, and column walls 1004 which form triangular hollow columns
15 1005. The reader should note that the columns of the various
16 figures are merely illustrative, and in practice, the columns
17 could be triangular, rectangular, square, pentagonal, hexagonal,
18 heptagonal, octagonal, round oval, n-sided or any other shape in
19 a cross section taken orthogonal to the longitudinal axis of a
20 column. The periphery of the cushioning element may also be
21 triangular, rectangular, square, pentagonal, hexagonal,
22 heptagonal, octagonal, round oval, heart shaped, kidney-shaped,
23 elliptical, oval, egg-shaped, n-sided or any other shape.

24 Figure 11 depicts a column 1101 of the invention including
25 column walls 1102 and 1103 and column interior 1104. The column
26 1101 has a longitudinal axis 1105 which is preferred to be
27 oriented in the invented cushion parallel to the direction of the
28 longitudinal axis of a column which should be the direction that

1 the cushioned object sinks into the cushion. Thus, the column
2 top 1106 is at the side of the cushion that contacts the
3 cushioned object, and the column bottom 1107 is at the side of
4 the cushion that typically faces the ground and will rest on some
5 sort of a base. Another way of describing this with respect to
6 the longitudinal axis of each column is that the column top is at
7 one end of the longitudinal axis of a column and the column
8 bottom is at the other end of the longitudinal axis of a column.
9 When an object to be cushioned is placed onto a cushion which
10 contains many such columns 1101, such as is shown in Figure 3, a
11 depressive force 1108 is applied to the cushion and to the column
12 1101 by the cushioned object. Because the cushion is expected to
13 rest on some type of supporting surface, such as a base, a
14 reaction force 1109 is provided by the supporting surface. The
15 cushion, including the column 1101, yields under the weight of
16 the cushioned object. This yielding is a result of compression
17 of the cushioning media and, if the load under a protruding
18 portion of the cushioned object is high enough, by buckling or
19 partial buckling of the columns 1101. From the figure, it can be
20 seen that the depicted column 1101 buckles because the flexible
21 cushion walls 1102 and 1103 buckle outward around the
22 circumference of the column, as depicted by cross-sectional
23 points 1110 and 1111. In other words, the column walls buckle
24 radially outward orthogonally from the longitudinal axis of the
25 column. This permits the column 1101 to decrease in total
26 length along its longitudinal axis 1108 and thereby conform to
27 the shape of protuberances on a cushioned object. Since buckled

1 columns carry comparatively little load, this results in a
2 cushion that avoids pressure peaks on the cushioned object.

3 Figure 12 depicts a column 1201 of the invention including
4 column walls 1202 and 1203 and column interior 1204. The column
5 1201 has a longitudinal axis 1205 which is preferred to be
6 oriented in the invented cushion parallel to the direction of
7 movement of a cushioned object sinking into the cushion. Thus,
8 the column top end 1206 is at the side of the cushion that
9 contacts the cushioned object, and the column bottom end 1207 is
10 at the side of the cushion that typically will rest on some sort
11 of a base. When an object to be cushioned is placed against a
12 cushion which contains numerous columns 1201, such as is shown in
13 Figure 3, a depressive force 1208 is applied to the cushion and
14 to the column 1201 by the cushioned object. Because the cushion
15 is expected to rest on some type of supporting surface, such as a
16 base, a reaction force 1209 is provided by the supporting
17 surface. The cushion, including the column 1201, yields under
18 the weight of the cushioned object. This yielding is a result of
19 compression of the cushioning media and, if the load under a
20 protruding portion of the cushioned object is high enough, by
21 buckling or partial buckling of the columns. From the figure, it
22 can be seen that the depicted column 1201 buckles because the
23 flexible cushion wall 1202 buckles outward from the column center
24 or orthogonal away from the longitudinal axis of the column at
25 point 1210, while cushion wall 1203 buckles inward toward the
26 column center or orthogonal toward the longitudinal axis of the
27 column at points 1211. This buckling action the column 1201 to
28 decrease in total length along its longitudinal axis 1208 and

1 thereby conform to the shape of protuberances on a cushioned
2 object. ~~Point 1210~~ is depicted buckling outward (away from the
3 center of the column) and ~~point 1211~~ is depicted as buckling
4 inward (toward the center of the column). Alternatively, both
5 points 1210 and 1211 could buckle inward toward the center of the
6 column or both could buckle outward. Since buckled columns carry
7 comparatively little load, this results in a cushion that avoids
8 pressure peaks on the cushioned object. Buckling of a column
9 permits the column to decrease in total length along its
10 longitudinal axis and thereby conform to the shape of
11 protuberances on a cushioned object. This results in a cushion
12 that avoids pressure peaks on the cushioned object. It should be
13 noted by the reader that the columns 1101 and 1201 depicted in
14 Figure 11 and 12 are hollow columns which have interiors
15 completely open to the atmosphere and which permit air to travel
16 through the columns to enhance ventilation under the cushioned
17 object. It is also of note that the column 1201 of Figure 12 has
18 column walls 1202 and 1203 that include fenestrations 1210 (which
19 may be holes or apertures in the column walls) that permit the
20 flow of air between adjacent columns, providing an enhanced
21 ventilation effect. The fenestrations or holes 1210 in the
22 column walls could be formed by punching or drilling, or they
23 could be formed during molding of the cushioning element.

24 Figure 13 depicts an alternative column 1301 of the
25 invention including column walls 1302 and 1303 and column
26 interior 1304. The column 1301 has a longitudinal axis 1305
27 which is preferred to be oriented in the invented cushion
28 parallel to the direction in which the cushioned object is

1 expected to sink into the cushion. Thus, the column top end 1306
2 is at the side of the cushion that contacts the cushioned object,
3 and the column bottom end 1307 is at the side of the cushion that
4 typically faces some sort of a base. When a object to be
5 cushioned is placed onto a cushion which contains column 1301,
6 such as is shown in Figure 3, a depressive force 1308 is applied
7 to the cushion and to the column 1301 by the cushioned object.
8 Because the cushion is expected to rest on some type of
9 supporting surface, such as a base, a reaction force 1309 is
10 provided by the supporting surface. The cushion, including the
11 column 1301, yields under the weight of the cushioned object.
12 This yielding is a result of compression of the cushioning media
13 and, if the load under a protruding portion of the cushioned
14 object is high enough, by buckling or partial buckling of the
15 columns. From the figure, it can be seen that the depicted
16 column 1301 buckles because the flexible cushion walls 1302 and
17 1303 buckle outward from the column center or orthogonal away
18 from the longitudinal axis 1305 of the column at points 1311 and
19 1310. This buckling action allows the column 1301 to decrease
20 in total length along its longitudinal axis 1305 and thereby
21 conform to the shape of protuberances on a cushioned object.

22 In the embodiment depicted, the column 1301 is a sealed
23 column containing air or an inert gas within its interior 1304.
24 Thus, as the column 1301 decreases in length along its
25 longitudinal axis, the gas within the column interior 1304 tends
26 to support the column top end 1306 and resist the downward
27 movement of the cushioned object. This yields a firmer cushion.
28 Alternatively, open or closed cell (or other) foam or fluid

1 cushioning media could be provided within the interior of the
2 columns or within some of them in order to increase the firmness
3 of the cushion.

4 Figure 14 depicts an alternative embodiment of the column of
5 the invention. The column 1401 depicted has column walls 1402
6 and 1403 and column interior 1404. The column 1401 has an
7 interior 1404 that is open at column top end 1405 and at column
8 bottom end 1406 to permit air to pass through the column 1401.
9 This column has walls 1402 and 1403 which are thicker at their
10 bottom end 1406 than at their top end 1405. This provides a
11 cushion that has a soft cushioning effect when cushioning an
12 object that sinks into the cushion to only a shallow depth, but
13 progressively provides firmer cushioning the deeper the cushioned
14 object sinks. This would permit a cushion to be constructed that
15 accomodates cushioned object of a very wide variety of weight
16 ranges. Alternatively, the column walls could be thicker at the
17 top than at the bottom, the column walls could be stepped, or the
18 column walls could have annular or helical grooves in them to aid
19 in buckling under a cushioned object. Additionally, the column
20 interior could be of a greater interior dimension orthogonal to
21 its longitudinal axis at one end than at the other. Or the
22 columns could be of varying dimension and shape along their
23 longitudinal axes.

24 Figure 15 depicts a cross section of a cushioning element
25 using alternating stepped columns. The cushioning element 1501
26 has a plurality of columns 1502 each having a longitudinal axis
27 1503, a column top 1504 and a column bottom 1505. The column top
28 1504 and column bottom 1505 are open in the embodiment depicted,

1 and the column interior or column passage 1506 is unrestricted to
2 permit air flow through the column 1502. The column 1502
3 depicted has side walls 1507 and 1508, each of which has three
4 distinct steps 1509, 1510 and 1511. The columns are arranged so
5 that the internal taper of a column due to the step on its walls
6 is opposite to the taper of the next adjacent column. This type
7 of cushioning element could be made using a mold similar to that
8 depicted in Figure 4.

9 Figure 16 depicts an alternative embodiment of a cushioning
10 element 1601. The cushioning element 1601 has a plurality of
11 columns 1602, 1603 and 1604, each having a column interior 1605,
12 1606 and 1607, and column walls 1608, 1609, 1610 and 1611. The
13 column walls are of course made from cushioning media, such as
14 the preferred soft gel. In the embodiment of the invented
15 cushioning element 1601 depicted, the cushioning media 1612 has
16 trapped within it a plurality of gas bubbles 1613, 1614 and 1615.
17 When the preferred soft gel cushioning media is used, since the
18 gel is not flowable at the temperatures to which the cushion is
19 expected to be exposed during use, the bubbles remain trapped
20 within the cushioning media. The use of bubbles within the
21 cushioning media is to provide a cushion which is lighter weight
22 and softer than might otherwise be available. Bubbles may be
23 introduced into the cushioning media by injecting air or another
24 appropriate gas into the cushioning media before manufacturing
25 the cushioning element, by vigorously stirring the heated,
26 flowable cushioning media before it is formed into the shape of a
27 cushion, or by utilizing a cushioning media of a composition that

1 creates gas or boils at the temperatures to which it is subjected
2 during the manufacture of a cushioning element.

3 Figure 17 depicts an embodiment of the invented cushioning
4 element which has cushioning media, solid exterior walls 1703 and
5 1704, a plurality of columns 1705 and column walls 1706 forming
6 the columns. Note that although the figure shows a cushioning
7 element 1701 with solid walls 1703 and 1704, it is possible to
8 make a cushioning element 1701 that has columns on its outer
9 walls. The cushioning element is within an optional cover 1707.
10 A container 1708 with relatively stiff or rigid walls 1709 and
11 1710 of approximately the same size and shape as the cushioning
12 element walls 1703 and 1704 is shown. The container 1708 has a
13 bottom or base 1711 on which the cushioning element is expected
14 to rest. The container 1708 walls 1709 and 1710 serve to
15 restrict the outward movement of the cushioning element 1701 when
16 a cushioned object is placed on it. When the preferred soft gel
17 is used as a cushioning media, the cushioning element 1701 would
18 tend to be displaced by the object being cushioned were the side
19 walls 1709 and 1710 of the container 1711 not provided. In lieu
20 of a container, any type of appropriate restraining means may be
21 used to prevent side displacement of the cushioning element in
22 response to the deforming force of a cushioned object. For
23 example, individual plastic plates could be placed against the
24 side walls 1703 and 1704 of the cushioning element 1701. Those
25 plates could be held in place with any appropriate holder, such
26 as the cover 1707. As another example, an appropriate strap or
27 girdle could be wrapped around all exterior side walls 1703 and
28 1704 of the cushioning element 1701. Such a strap or girdle

1 would serve to restrain the cushioning element 1701 against
2 radial outward displacement in response to a cushioned object
3 resting on the cushioning element.

4 Figure 18 depicts an alternative embodiment of a cushion
5 1801 that includes a cushioning element 1802 and a cover 1803.
6 The cushioning element 1802 has side walls 1808 and 1809 about
7 its periphery, the side walls 1808 and 1809 in this embodiment
8 being generally parallel with the longitudinal axis 1810 of a
9 hollow column 1811 of the cushioning element 1802. A gap 1806
10 exists between the cover 1803 and the side wall 1809 of the
11 cushioning element. This gap 1806 accomodates the insertion of a
12 stiff or rigid reinforcing side wall support 1804 which may be
13 made of a suitable material such as plastic, wood, metal or
14 composite material such as resin and a reinforcing fiber.
15 Similarly, gap 1807 between side wall 1808 and the cover 1803 may
16 have side wall support 1805 inserted into it. The side wall
17 supports are configured to restrict the cushioning element from
18 being substantially displaced in an outward or radial direction
19 (a direction orthogonal to the longitudinal axis of one of the
20 columns of the cushioning element) so that the cushioning
21 element's columns will buckle to accomodate the shape of a
22 cushioned object, rather than permitting the cushioning element
23 to squirm out from under the cushioned object.

24 Figure 19 depicts an alternative embodiment of a cushioning
25 element 1901 including square columns 1908. The cushioning
26 element has outer side walls 1902 and 1903 about its periphery.
27 The reader should note that although the outer periphery of the
28 cushioning element in this figure is depicted as rectangular, the

1 outer periphery could be of any desired configuration, such as
2 triangular, square, pentagonal, hexagonal, heptagonal, octagonal,
3 any n-sided polygon shape, round, oval, elliptical, heart-shaped,
4 kidney-shaped, quarter moon shaped, n-sided polygonal where n is
5 an integer, or of any other desired shape. The side walls 1902
6 and 1903 of the cushioning element 1901 have a peripheral strap
7 or girdle 1904 about them. The girdle 1904 has reinforcing side
8 walls 1905 and 1906 which reinforce the structural stability of
9 side walls 1902 and 1903 respectively of the cushioning element
10 1901. The embodiment of the girdle 1904 depicted in the figure
11 has a fastening mechanism 1907 so that it may be fastened about
12 the periphery of the cushioning element 1901 much as a person
13 puts on a belt. The girdle 1904 serves to confine the cushioning
14 element 1901 so that when a cushioned object is placed on the
15 cushioning element 1901, the cushioning element will not tend to
16 squirm out from beneath the girdle 1904. Thus, the cushioning
17 element 1901 will tend to yield and conform to the cushioned
18 object as needed by having its cushioning media compress and its
19 columns buckle.

20 Figure 20 depicts an alternative embodiment of a cushioning
21 element 2001. The cushioning element 2001 includes cushioning
22 media 2002 such as the preferred gel formed into column walls
23 2003 and 2004 to form a column 2005. The column 2005 depicted
24 has a sealed column top 2006 and a sealed column bottom 2007 in
25 order to contain a column filler 2008. The column filler 2008
26 could be open or closed cell foam, any known fluid cushioning
27 media such as lubricated spherical objects, or any other desired
28 column filler. The cushioning element 2001 depicted has an

1 advantage of greater firmness compared to similar cushioning
2 elements which either omit the sealed column top and column
3 bottom or which omit the column filler.

4 Figure 21 depicts an alternative embodiment of a cushioning
5 element 2101 of the invention. The cushioning element 2101 has
6 cushioning media 2102 formed into column walls 2103 and 2104.
7 The column walls 2103 and 2104 form a column interior 2105. The
8 column 2106 has an open column top 2107 and a closed column
9 bottom 2108. In the embodiment depicted, the column 2107 has a
10 firmness protrusion 2109 protruding into the column interior 2105
11 from the column bottom 2108. The firmness protrusion 2109
12 depicted is wedge or cone shaped, but a firmness protrusion could
13 be of an desired shape, such as cylindrical, square, or otherwise
14 in cross section along its longitudinal axis. The purpose of the
15 firmness protrusion 2109 is to provide additional support within
16 a buckled column for the portion of a cushioned object that is
17 causing the buckling. When a column of this embodiment of the
18 invention buckles, the cushioning element will readily yield
19 until the cushioned object begins to compress the firmness
20 protrusion. At that point, further movement of the cushioned
21 object into the cushion is slowed, as the cushioning media of the
22 firmness support needs to be compressed or the firmness support
23 itself needs to be caused to buckle in order to achieve further
24 movement of the cushioned object into the cushioning media.

25 It is contemplated in the invention that typically the
26 hollow portion of the column will be of uniform cross section
27 throughout its length, but this is not necessary for all
28 embodiments of the invention. For example, in a column having a

1 circular cross section orthogonal to its longitudinal axis, the
2 diameter of the circle could increase along its length, and
3 adjacent columns could correspondingly decrease along their
4 length (i.e. the columns would be formed as opposing cones). As
5 another example, the column walls could all thicken from one
6 cushion surface to another to facilitate the use of tapered cores
7 (which create the hollow portion of the columns) in the
8 manufacturing tool, which tapering facilitates the removal of the
9 cores from the gel.

10 It is also preferred that the columns of the preferred
11 cushioning element be open at their top and bottom. However, the
12 columns can be bonded to or integral with a face sheet on the top
13 or bottom or both, over all or a portion of the cushion. Or the
14 columns can be interrupted by a sheet of gel or other material at
15 their midsection which is like a face sheet except that it cuts
16 through the interior of a cushioning element.

17 In the preferred embodiment of the cushioning element the
18 column walls are not perforated. However, perforated walls
19 and/or face sheets are within the scope of this invention. The
20 perforation size and density can be varied by design to control
21 column stiffness, buckling resistance, and weight, as well as to
22 enhance air circulation.

23 It is also preferred that the wall thickness of the columns
24 be approximately equal throughout the cushioning element for
25 uniformity, but in special applications of the invented cushion,
26 wall thickness may be varied to facilitate manufacturing or to
27 account for differing expected weight loads across the cushion or
28 for other reasons.

1 Typical cushions in the art are ordinarily one piece, but
2 the invented cushion can be constructed from more than one
3 discontinuous cushioning element of the invention. ~~f~~or example, M
4 three one-inch thick cushions of this invention can be stacked to
5 make a three-inch thick cushion of this invention, with or
6 without other materials between the layers, and with or without
7 connecting the three layers to one another.

8 The cushioning element of this invention can be used alone
9 or with a cover. A cover can be desirable when used to cushion a
10 human body to mask the small pressure peaks at the edges of the
11 column walls. This is not necessary if the gel used is soft
12 enough to eliminate these effects, but may be desirable if firmer
13 gels are used. Covers can also be desirable to keep the gel
14 (which can tend to be sticky) clean. If used, a cover should be
15 pliable or stretchable so as not to overly reduce the gross
16 cushioning effects of the columns compressing and/or buckling.
17 The preferred cover would also permit air to pass through it to
18 facilitate air circulation under the cushioned object.

19 While it is envisioned that the immediate application of the
20 invented cushion is to cushion human beings (e.g., seat cushions,
21 mattresses, wheelchairs cushions, stadium seats, operating table
22 pads, etc.), animals (e.g. between a saddle and a horse),
23 manufactured products (e.g., padding between a manufactured
24 product and a shipping container), and other objects may be
25 efficiently cushioned using the invention.

26 It is preferred that columns in the invented cushion be
27 oriented with their longitudinal axis generally parallel to the
28 direction of gravity so that they will buckle under load from a

1 cushioned object rather than collapse from side pressure. It is
2 also preferred that some type of wall or reinforcement be
3 provided about the periphery of the cushioning element in order
4 to add stability to the cushioning element and in order to ensure
5 that the buckling occurs in order to decrease column length under
6 a cushioned object.

7 In some embodiments of the invention, a perforated column
8 wall is provided to enhance the flow of air through the columns
9 and in order to enhance the circulation of air between the
10 cushion and the cushioned object. Fenestrated column walls may
11 be provided to permit air flow from cell to cell and to thus
12 further enhance air circulation. In other embodiments of the
13 invention, multiple cushioning elements are provided within a
14 single cushion.

15 The invented cushioning element may be described as a
16 gelatinous elastomeric or viscoelastomeric material (i.e. gel)
17 configured as laterally connected hollow vertical columns which
18 elastically sustain a load up to a limit, and then buckle beyond
19 that limit. This produces localized buckling in a cushioning
20 element beneath a cushioned object depending upon the force
21 placed upon the cushioning element in a particular location. As
22 a result, protruding portions of the cushioned object can
23 protrude into the cushion without being subjected to pressure
24 peaks. As a result, the cushioning element distributes its
25 supportive pressure evenly across the contact area of the
26 cushioned object. This also maximizes the percentage of the
27 surface area of the cushioned object that is in contact with the
28 cushion.

1 In the preferred embodiments, each individual column wall
2 can buckle, markedly reducing the load carried by that column and
3 causing each column to be able to conform to protuberances of the
4 cushioned object. Buckling may be described as the localized
5 crumpling of a portion of a column, or the change in primary
6 loading of a portion of a column from compression to bending. In
7 designing structural columns, such as concrete or steel columns
8 for buildings or bridges, the designer seeks to avoid buckling
9 because once a column has buckled, it carries far less load than
10 when not buckled. In the columns of this cushion, however,
11 buckling works to advantage in accomplishing the objects of the
12 invention. The most protruding parts of the cushioned object
13 cause the load on the columns underneath them to have a higher
14 than average load as the object initially sinks into the cushion.
15 This higher load causes the column walls immediately beneath the
16 protruding portion of the cushioned object to buckle, which
17 markedly reduces the load on the protruding portion. The
18 surrounding columns, which have not exceeded the buckling
19 threshold, take up the load which is no longer carried by the
20 column(s) beneath the most protruding portion of the cushioned
21 object.

22 As an example of the desirability of the buckling provided
23 by the cushioning element of the invention, consider the dynamics
24 of a seat cushion. The area of a seated person which experiences
25 the highest level of discomfort when seated without a cushion
26 (such as on a wooden bench) or on a foam cushion is the tissue
27 that is compressed beneath the most protruding bones (typically
28 the ischial tuberosities). When the invented cushioning element

1 is employed, the area beneath the protruding portions will have
2 columns that buckle, but the remainder of the cushioning element
3 should have columns (which are beneath the broad, fleshy non-bony
4 portion of the person's posterior) which will withstand the load
5 placed on them and not buckle. Since the broad fleshy area over
6 which the pressure is substantially equal is approximately 95% of
7 the portion of the person subjected to sitting pressure, and the
8 area beneath the ischial tuberosity is subjected to less than
9 average pressured due to the locally buckled gel columns (in
10 approximately 5% of that area), the person is well supported and
11 the cushion is very comfortable to sit on.

12 As another example, consider the cushioning element of the
13 invention used in a bed mattress. The shoulders and hips of a
14 person lying on his/her side would buckle the columns in the
15 cushioning element beneath them, allowing the load to be picked
16 up in the less protruding areas of the person's body such as the
17 legs and abdomen. A major problem in prior art mattress cushions
18 is that the shoulders and hips experience too much pressure and
19 the back is unsupported because the abdomen receives too little
20 pressure. The cushion of this invention offers a solution to
21 this problem by tending to equalize the pressure load through
22 local buckling under protruding body parts.

23 It is most preferred to use the square columns of Figures 7
24 or 8 in the invented cushion because square columns are believed
25 by the inventor to be the best balance between lateral stability
26 (resistance to collapse from side loads) and light weight (which
27 also corresponds to good air circulation and low thermal
28 transfer). Some other types of columns such those depicted in

1 the other figures or mentioned elsewhere herein have more
2 cushioning media (typically gel) per cubic inch of cushion for a
3 given level of cushioning support. Thus, the resulting cushions
4 are heavier and have a higher rate of thermal transfer. They are
5 also more costly to manufacture due to the increased amount of
6 cushioning media required. However, columns with oval, circular
7 or triangular cross sections are preferred for some cushioning
8 applications because they have a greater degree of lateral
9 stability than square or honeycomb columns because triangles form
10 a braced structure and circles and ovals form structurally sound
11 arches when considered from a lateral perspective. Honeycomb
12 columns such as those shown in Figures 2, 4, 5, 7, 8, 9 and 10
13 generally have the least gel per cubic inch of cushion for a
14 given level of support, but have little lateral stability.
15 However, they can be the preferred embodiment in any cushioning
16 application which has need for lightest weight and does not
17 require substantial lateral stability.

18 The cushions of this invention differ from prior art gel
19 cushions in that while prior art gel cushions come in a variety
20 of shapes, all are essentially a solid mass. When a cushioned
21 object attempts to sink into a prior art gel cushion, the cushion
22 either will not allow the sinking in because the non-contact
23 portions of the cushion are constrained from expanding, or the
24 cushion expands undesirably. In the cushion of this invention,
25 the gel has enough hollow space to allow sinking in without
26 expanding the borders of the cushion, so the problem is
27 alleviated.

1 Another problem with prior art gel cushions is the weight.
2 For example, a wheelchair cushion made of prior art gel with
3 dimensions of 18" x 16" x 3.5" would weigh 35-40 pounds, which is
4 unacceptable to wheelchair users. The same dimension cushion of
5 this invention would weigh approximately seven pounds. To be an
6 acceptable weight for wheelchairs, a typical prior art wheelchair
7 gel cushion is made only 1" thick. To prevent bottoming out
8 through such a thin cushion, the makers increase the rigidity of
9 the gel, which ruins the ability of the gel to equalize pressure
10 through semi-hydrostatic characteristics, and the cushions thus
11 relieve pressure no better than a foam cushion. The cushion of
12 this invention can be the preferred full 3.5 inches thick needed
13 to allow sinking in for a human user which is in turn needed to
14 equalize pressure and increase the surface area under pressure,
15 while still being light weight.

16 The cushions of this invention differ from prior art
17 honeycomb cushions in part in that gel is used instead of
18 thermoplastic or thermoplastic elastomer. Also, a comparatively
19 thick gel is used for the walls of the columns, as compared to
20 very thin films made of comparatively much more rigid
21 thermoplastic film or thermoplastic elastomer film. If thick
22 walls were used in prior art honeycomb cushions, the rigidity of
23 available thermoplastics and available thermoplastic elastomers
24 would cause the cushion to be far too stiff for typical
25 applications. Also, the use of comparatively hard, thin walls
26 puts the cushioned object at increased risk. When the load on a
27 prior art honeycomb cushion exceeds the load carrying capability
28 of virtually all of the columns (i.e., they all buckle), the

1 cushioned object bottoms out onto a relatively hard, rigid, thin
2 pile of thermoplastic film layers. In that condition, the
3 cushioned object is subjected to pressures similar to the
4 pressures it would experience with no cushion at all. The
5 cushioned object is thus at risk of damaging pressures on its
6 most protruding portions. In comparison, if the same bottoming
7 out occurs on the cushion of this invention, the most protruding
8 portions of the cushioned object would be pressed into a pile of
9 relatively thick, soft gel layers, which would add up to
10 typically 20% of the original thickness of the cushion. Thus,
11 the risk of bottoming out is substantially lowered.

12 Another difference between prior art thermoplastic honeycomb
13 cushions and the cushion of this invention is that the
14 configuration of the invented cushion is not limited to honeycomb
15 columns, but can take advantage of the varying properties offered
16 by columns of virtually any cross sectional shape. The prior art
17 thermoplastic honeycomb cushions are so laterally unstable that
18 at least one face sheet must be bonded across the open cells.
19 This restricts the air circulation, which is only somewhat
20 restored if small perforations are made in the face sheet or
21 cells. While face sheets and perforations are an option on the
22 cushions of this invention, the alternative cross sectional
23 shapes of the columns (e.g., squares or triangles) make face
24 sheets unnecessary due to increased lateral stability and thus
25 perforations are unnecessary since both ends of the column are
26 open to the atmosphere.

27 The maximum thickness of the walls of the columns of the
28 cushion of this invention should be such that the bulk density of

1 the cushion is less than 50% of the bulk density if the cushion
2 were completely solid gel. Thus, at least 50% of the volume of
3 space occupied by the invented cushioning element is occupied by
4 a gas such as air and the remainder is occupied by gel. The
5 minimum thickness of the walls of the columns is controlled by
6 three factors: (1) manufacturability; (2) the amount of gel
7 needed for protection of the cushioned object in the event of all
8 columns buckling; and (3) the ability to support the cushioned
9 object without buckling the majority of the columns. The
10 preferred thickness would be such that the columns under the most
11 protruding parts of the cushioned object are buckled, and the
12 remaining columns are compressed in proportion to the degree of
13 protrusion of the cushioned object immediately above them but are
14 not buckled.

15 **B. Materials of Construction of the Cushions**

16 It is preferred that the cushioning media used to
17 manufacture the invented cushioning element be a soft gel. This
18 assures that the invented cushion will yield under a cushioned
19 object by having buckling columns and by the cushioning media
20 itself compressing under the weight of the cushioned object. The
21 semi-hydrostatic nature of the soft gel will provide additional
22 cushioning and will accomodate uneven surfaces on the cushioned
23 object. However, firmer gels are also usable within the
24 invention provided that the gel is soft enough to provide
25 acceptable cushioning for the particular object in the event that
26 all columns buckle. Since with a given type of gel there is
27 typically a correlation between softness and Young's modulus
28 (stiffness), i.e., a softer gel is less stiff, and since there is

1 a correlation between Young's modulus and the load carrying
2 capability of a column before buckling, there is typically a need
3 to have a firmer gel in a cushion that needs to carry a higher
4 load. However, there are other alternatives for increasing a
5 cushion's load carrying capability, such as increasing the column
6 wall thickness, so that the softness of the gel can be selected
7 for its cushioning characteristics and not solely its load
8 bearing characteristics, particularly in cases where cushion
9 weight is not a factor. Any gelatinous elastomer or gelatinous
10 viscoelastomer with a hardness on the Shore A scale of less than
11 15 may be considered a gel for the purposes of this invention,
12 though a hardness of 3 or less on the Shore A scale is preferred,
13 and a hardness which is off the Shore A scale and is
14 characterized by a gram Bloom of less than about 800 is much
15 preferred. Gram Bloom is defined as the gram weight required to
16 depress a gel a distance of 4 mm with a piston having a cross
17 sectional area of 1 square centimeter at 23 degrees Celsius. The
18 preferred gel is non-flowable at the normal usable temperatures
19 of a cushioning element which is used to cushion a human being,
20 and the preferred gel will not escape from the cushioning element
21 if the cushioning element is punctured. The preferred gel has
22 shape memory so that it tends to return to its original shape
23 after deformation.

24 The cushioning media or preferred gel must also be strong
25 enough to withstand the loads and deformations expected during
26 the use of the cushion. For a given type of gel, there is
27 typically a correlation between softness and strength, i.e., the
28 softer gels are not as strong as harder gels.

1 Because of its high strength even in soft formulations, its
2 low cost, its ease of manufacture, the variety of manufacturing
3 methods which can be used, and the wide range of Young's modulus
4 which can be formulated while keeping the hydrostatic
5 characteristics of a gel, the gel formulations of the following
6 patents are the most preferred gels to be used in the cushions of
7 this invention: United States Patent No. 5,334,646 issued in the
8 name of Chen on August 2, 1994; United States Patent No.
9 4,369,284 issued in the name of Chen on January 18, 1983; United
10 States Patent No. 5,262,468 issued in the name of Chen on
11 November 16, 1993; United States Patent No. 4,618,213 issued in
12 the name of Chen on October 21, 1986; and United States Patent
13 No. 5,336,708 issued in the name of Chen on August 9, 1994, each
14 of which is hereby incorporated by reference in its entirety.

15 These formulations comprise about 100 parts by weight of a
16 high viscosity triblock copolymer of the general configuration
17 poly(styrene-ethylene-butylene-styrene) and from about 200 to
18 about 1600 parts by weight of a plasticizing oil such as mineral
19 oil. These formulations are very soft to the touch and very
20 pliable to enable column buckling of even relatively thick
21 columns, yet are so strong that they can stretch as much as
22 sixteen times their original length without fracture. Varying
23 the amount of plasticizing oil varies the softness and Young's
24 modulus, so that the designer of the cushion of this invention
25 has a wide range of gels from which to select. There are many
26 additives and variations discussed in the patents above which can
27 impart varying characteristics to the gel.

1 The high viscosity triblock copolymers employed in the
2 preferred gel have the more general configuration A-B-A wherein
3 each A is a crystalline polymer end block segment of polystyrene;
4 and B is a elastomeric polymer center block segment of
5 poly(ethylene-butylene). The poly(ethylene-butylene) and
6 polystyrene portions are incompatible and form a two-phase system
7 consisting of sub-micron domains of glassy polystyrene
8 interconnected by flexible poly(ethylene-butylene) chains. These
9 domains serve to crosslink and reinforce the structure. This
10 physical elastomeric network structure is reversible, and heating
11 the polymer above the softening point of polystyrene temporarily
12 disrupt the structure, which can be restored by lowering the
13 temperature. Reviews of triblock copolymers are found in the
14 "ENCYCLOPEDIA OF POLYMER SCIENCE AND ENGINEERING", Volume 2 and
15 5, 1987-1988; "Thermoplastic Elastomers", MODERN PLASTIC
16 ENCYCLOPEDIA, 1989; and Walker, B. M., Ed., et al., HANDBOOK OF
17 THERMOPLASTIC ELASTOMERS, Van Nostrand Reinhold Co., 2nd Edition,
18 1988. These publications are incorporated herein by reference).

19 Some high viscosity triblock copolymers in (A) which are
20 suitable for use in the preferred gel invention have a typical
21 Brookfield Viscosity of a 20 weight percent solids Solution in
22 toluene at 25° C. of not less than about 1,800 cps, and
23 preferably about 2,000 cps or higher. Typically, the Brookfield
24 Viscosity values of (A) can range from about 1,800 cps to about
25 16,000 cps. Less typically, the Brookfield Viscosity values of
26 (A) can range from about 1,800 cps to about 30,000 cps or higher.
27 The proportion of hydrocarbon plasticizing oil in (B) is more

1 preferably from about 350 to about 1,600 parts per 100 parts of
2 the copolymer.

3 The high viscosity triblock copolymer of the preferred gel
4 can have a broad range of styrene end block to ethylene and
5 butylene center block ratio of approximately about 20:80 or less
6 to about 40:60 or higher. Examples of high viscosity copolymers
7 that can be utilized to achieve one or more of the novel
8 properties of the present invention are
9 styrene-ethylene-butylene-styrene block copolymers (SEBS)
10 available from Shell Chemical Company and Pecten Chemical Company
11 (divisions of Shell Oil Company) under trade designations Kraton
12 G 1651, Kraton G 4600, Kraton G 4609 and the like. Other grades
13 of (SEBS) polymers can also be utilized in the present invention
14 provided such SEBS polymers exhibits the required high viscosity.
15 Such SEBS polymers include (high viscosity) Kraton G 1855X which
16 has a Specific Gravity of 0.92, Brookfield Viscosity of a 25
17 weight percent solids solution in toluene at 25° C. of about
18 40,000 cps or about 8,000 to about 20,000 cps at a 20
19 weight percent solids solution in toluene at 25° C.

20 The styrene to ethylene and butylene weight ratios for these
21 Shell designated polymers can have a low range of 20:80 or less.
22 Although the typical ratio values for Kraton G 1651, 4600, and
23 4609 are approximately about 33:67 and for Kraton G 1855X
24 approximately about 27:73, these ratios can vary broadly from the
25 typical product specification values. The styrene to ethylene and
26 butylene weight ratio of SEBS useful in forming the gelatinous
27 elastomer composite articles can range from lower than about
28 20:80 to above about 40:60. More specifically, the values can be

1 19:81, 20:80, 21:79, 22:78, 23:77, 24:76, 25:75, 26:74, 27:73,
2 28:72, 29:71, 30:70, 31:69, 32:68, 33:67, 34:66, 35:65, 36:64,
3 37:63, 38:62, 39:61, 40:60, 41:59, 42:58, 43:57, 44:65, 45:55,
4 46:54, 47:53, 48:52, 49:51, 50:50, 51:49 and higher. Other ratio
5 values of less than 19:81 or higher than 51:49 are also possible.
6 Broadly, the styrene end block to ethylene and butylene center
7 block ratio of the triblock copolymers of the invention is
8 about 20:80 to about 40:60, less broadly about 31:69 to about
9 40:60, preferably about 32:68 to about 38:62, more preferably
10 about 32:68 to about 36:64, particularly more preferably about
11 32:68 to about 34:66, especially more preferably about 33:67 to
12 about 36:64, and most preferably about 33:67. Triblock
13 copolymers having ratios below 31:69 may be used, but they are
14 less preferred due to their decrease in the desirable properties
15 of the final composition.

16 Plasticizers particularly preferred for making the preferred
17 gel are well known in the art, they include rubber processing
18 oils such as paraffinic and naphthenic petroleum oils, highly
19 refined aromatic-free paraffinic and naphthenic food and
20 technical grade white petroleum mineral oils, and synthetic
21 liquid oligomers of polybutene, polypropene, polyterpene, etc.
22 The synthetic series process oils are high viscosity oligomers
23 which are permanently fluid liquid nonolefins, isoparaffins or
24 paraffins of moderate to high molecular weight. Many such oils
25 are known and commercially available. Examples of representative
26 commercially oils include Amoco Registered TM polybutenes,
27 hydrogenated polybutenes and polybutenes with epoxide
28 functionality at one end of the polybutene polymer: Examples of

1 such polybutenes include: L-14 (320 M n), L-50 (420 M n), L-100
2 (460 M n), H-15 (560 M n), H-25 (610 M n), H-35 (660 M n), H-50
3 (750 M n), H-100 (920 M n), H-300 (1290 M n), L-14E (27-37 cst @
4 100° F. Viscosity), L-300E (635-690 cst @ 210° F. Viscosity),
5 Actipol E6 (365 M n), E16 (973 M n), E23 (1433 M n) and the like.
6 Examples of various commercially available oils include: ARCO
7 Prime and Tufflo oils, other white mineral oils include: Bayol,
8 Bernol, American, Blandol, Drakeol, Ervol, Gloria, Kaydol,
9 Litetek, Marcol, Parol, Penetack, Primol, Protol, Sonrex, and the
10 like.

11 The high viscosity triblock copolymer component by itself
12 lacks the desired properties; whereas, when the triblock
13 copolymer (having Brookfield Viscosities of a 20 weight percent
14 solids solution in toluene at 25° C. of about 1,800 cps or higher
15 and styrene to ethylene and butylene ratio preferably of the
16 range contemplated in the instant invention) is combined with
17 selected plasticizing oils with an average molecular weight
18 preferably of about 200 to about 700, as determined by
19 ebulliscopic methods, wherein, for most purposes, the oil
20 constitutes about 300 to about 1,600 parts and more preferably
21 about 350 to about 1,600 parts by weight of the triblock
22 copolymer, that an extremely soft and highly elastic material is
23 obtained. This transformation of the triblock copolymer
24 structure in heated oil resulting in a composition having a gel
25 rigidity preferably of about 20 gram or lower to about 800 gram
26 Bloom and substantially without oil bleedout along with high
27 tensile strength and elongation and other desirable combination
28 of physical properties is unexpected. As used herein, the term

1 "gel rigidity" in gram Bloom is determined by the gram weight
2 required to depress a gel a distance of 4 mm with a piston having
3 a cross-sectional area of 1 square centimeter at 23° C.

4 The aforementioned molecular weight range plasticizing oils
5 are most preferred. Generally, plasticizing oils with average
6 molecular weights less than about 200 and greater than about 700
7 may also be used.

8 The preferred gel can be conductive or non-conductive,
9 containing conductive fillers (carbon, metal flakes etc.) or
10 non-conductive fillers. The gel can also contain useful amounts
11 of conventionally employed additives such as stabilizers,
12 antioxidants, antiblocking agents, colorants, fragrances, flame
13 retardants, other polymers in minor amounts and the like to an
14 extend not affecting or substantially decreasing the desired
15 properties of the present invention.

16 Additives useful in the preferred gel include:
17 tetrakis[methylene 3, -(3'5'-di-tertbutyl-4"-hydroxyphenyl)
18 propionate]methane, octadecyl
19 3-(3",5"-di-tert-butyl-4"-hydroxyphenyl) propionate,
20 distearyl-pentaerythritoldipropionate, thiodiethylene
21 bis-(3,5-ter-butyl-4-hydroxy) hydrocinnamate,
22 (1,3,5-trimethyl-2,4,6-tris[3,5-di-tert-butyl-4-hydroxybenzyl]ben
23 zene), 4,4"-methylenebis(2,6-di-tert-butylphenol), stearic acid,
24 oleic acid, stearamide, behenamide, oleamide, erucamide,
25 N,N"-ethylenebisstearamide, N,N"-ethylenebisoleamide, sterryl
26 erucamide, erucyl erucamide, oleyl palmitamide, stearyl
27 stearamide, erucyl stearamide, waxes (e.g. polyethylene,

1 polypropylene, microcrystalline, carnauba, paraffin, montan,
2 candelila, beeswax, ozokerite, ceresine, and the like). Minor
3 amounts of other polymers and copolymers can be melt blended with
4 the styrene-ethylene-butylene-styrene block copolymers mentioned
5 above without substantially decreasing the desired properties.
6 Such polymers include (SBS) styrene-butadiene-styrene block
7 copolymers, (SIS) styrene-isoprene-styrene block copolymers, (low
8 styrene content SEBS) styrene-ethylene-butylene-styrene block
9 copolymers, (SEP) styrene-ethylene-propylene block copolymers,
10 (SB)_n styrene-butadiene and (SEB)_n, (SEBS)_n, (SEP)_n, (SI)_n
11 styrene-isoprene multi-arm, branched, and star shaped
12 copolymers and the like. Still, other homopolymers can be
13 utilized in minor amounts; these include: polystyrene,
14 polybutylene, polyethylene, polypropylene and the like. The
15 composition can also contain metallic pigments (aluminum and
16 brass flakes), TiO₂, mica, fluorescent dyes and pigments,
17 phosphorescent pigments, aluminatetrihydrate, antimony oxide, iron
18 oxides (Fe₃O₄, -Fe₂O₃, etc.), iron cobalt oxides, chromium
19 dioxide, iron, barium ferrite, strontium ferrite and other
20 magnetic particle materials, molybdenum, silicone fluids, lake
21 pigments, aluminates, ceramic pigments, ironblues, ultramarines,
22 phthalocynines, azo pigments, carbon blacks, silicon dioxide,
23 silica, clay, feldspar, glass microspheres, barium ferrite,
24 wollastonite and the like. The report of the committee on
25 Magnetic Materials, Publication NMAB-426, National Academy Press
26 (1985) is incorporated herein by reference.

27 The preferred gel is prepared by blending together the
28 components including other additives as desired at about 23° C.

1 to about 100° C. forming a paste like mixture and further heating
2 said mixture uniformly to about 150° C. to about 200° C. until a
3 homogeneous molten blend is obtained. Lower and higher
4 temperatures can also be utilized depending on the viscosity of
5 the oils and amount of SEBS used. These components blend easily
6 in the melt and a heated vessel equipped with a stirrer is all
7 that is required. Small batches can be easily blended in a test
8 tube using a glass stirring rod for mixing. While conventional
9 large vessels with pressure and/or vacuum means can be utilized
10 in forming large batches of the instant compositions in amounts
11 of about 40 lbs or less to 10,000 lbs or more. For example, in a
12 large vessel, inert gases can be employed for removing the
13 composition from a closed vessel at the end of mixing and a
14 partial vacuum can be applied to remove any entrapped bubbles.
15 Stirring rates utilized for large batches can range from about
16 less than 10 rpm to about 40 rpm or higher.

17 A high viscosity poly(styrene-ethylene-butylene-styrene)
18 triblock copolymer having styrene end block to ethylene and
19 butylene center block ratio preferably within the contemplated
20 range of from about 20:80 to about 40:60, more preferably from
21 between about 31:69 to about 40:60 when blended in the melt with
22 an appropriate amount of plasticizing oil makes possible the
23 attainment of gelatinous elastomer compositions having a
24 desirable combination of physical and mechanical properties,
25 notably high elongation at break of at least 1,600%, ultimate
26 tensile strength of about at least 8×10^5 dyne/cm², low
27 elongation set at break of substantially not greater than about
28 2%, tear resistance of at least 5×10^5 dyne/cm², substantially

1 about 100% snap back when extended to 1,200% elongation, and a
2 gel rigidity of substantially not greater than about 700 gram
3 Bloom. It should be noted that when the ratio falls below 31:69,
4 various properties such as elongation, tensile strength, tear
5 resistance and the like can decrease while retaining other
6 desired properties, such as gel rigidity, flexibility, elastic
7 memory.

8 More specifically, the preferred gel exhibits one or more of
9 the following properties. These are: (1) tensile strength of
10 about 8×10^5 dyne/cm² to about 10^7 dyne/cm²; (2) elongation of
11 about 1,600% to about 3,000% and higher; (3) elasticity modulus
12 of about 10^4 dyne/cm² to about 10^6 dyne/cm²; (4) shear modulus of
13 about 10^4 dyne/cm² to about 10^6 dyne/cm² as measured with a 1, 2,
14 and 3 kilogram load at 23° C.; (5) gel rigidity of about 20 gram
15 Bloom or lower to about 800 gram Bloom as measured by the gram
16 weight required to depress a gel a distance of 4 mm with a piston
17 having a cross-sectional area of 1 square cm at 23° C.; (6) tear
18 propagation resistance of at least about 5×10^5 dyne/cm²; (7)
19 and substantially 100% snap back recovery when extended at a
20 crosshead separation speed of 25 cm/minute to 1,200% at 23° C.
21 Properties (1), (2), (3), and (6) above are measured at a
22 crosshead separation speed of 25 cm/minute at 23° C.

23 Gelatinous elastomer articles molded from the instant
24 compositions have various additional important advantages in that
25 they tend not to crack, creep, tear, crack, or rupture in
26 flexural, tension, compression, or other deforming conditions of
27 normal use; but rather the cushioning element made from the
28 preferred gel possess the intrinsic properties of elastic memory

1 enabling it to recover and retain its original shape after many
2 extreme deformation cycles as compared to prior art triblock
3 copolymer oil-extended compositions. In applications where low
4 rigidity, high elongation, good compression set and excellent
5 tensile strength are important, the gel described above would be
6 preferred.

7 Generally the molten gelatinous elastomer composition will
8 adhere sufficiently to certain plastics (e.g. acrylic, ethylene
9 copolymers, nylon, polybutylene, polycarbonate, polystyrene,
10 polyester, polyethylene, polypropylene, styrene copolymers, and
11 the like) provided the temperature of the molten gelatinous
12 elastomer composition is sufficient high to fuse or nearly fuse
13 with the plastic. In order to obtain sufficient adhesion to
14 glass, ceramics, or certain metals, sufficient temperature is
15 also required (e.g. above 250° F.). Commercial resins which can
16 aid in adhesion to materials (plastics, glass, and metals) may be
17 added in minor amounts to the gelatinous elastomer composition,
18 these resins include: Super Sta-tac, Nevtac, Piccotac, Escorez,
19 Wingtack, Hercotac, Betaprene, Zonarez, Nirez, Piccolyte,
20 Sylvatac, Foral, Pentalyn, Arkon P, Regalrez, Cumar LX, Picco
21 6000, Nevchem, Piccotex, Kristalex, Piccolastic, LX-1035, and the
22 like.

23 The preferred gel of the invention is further illustrated by
24 means of the following illustrative embodiments, which are given
25 for purpose of illustration only and are not meant to limit the
26 invention to the particular components and amounts disclosed.

EXAMPLE I

A comparison can be made between a low viscosity poly(styrene-ethylene-butylene-styrene) triblock copolymer having styrene end block to ethylene and butylene center block ratio below the range between 31:69 to 40:60 and a high viscosity poly(styrene-ethylene-butylene-styrene) triblock copolymer. Three different triblock copolymers can be melt blended separately with a paraffinic white petroleum oil. Table I below shows the physical properties that should be obtained with respect to each of the different viscosity and styrene to ethylene and butylene ratio triblock copolymer oil-blends tested.

The properties to be measured are: Tear Propagation (ASTM D 19938 modified), Cracking (ASTM D 51 8 Method B modified), Tensile Strength (ASTM D 412 modified), Ultimate elongation (ASTM D 41 2 modified), Tensile Set (ASTM D 412 Modified), Compression Set (ASTM D 395 modified), Snap Back, and Hand Kneading (60 seconds).

TABLE I

Formulation	S/EB Ratio ¹	Weight Parts		
		A	B	C
SEBS ²	28:72	100		
SEBS ³	29:71		100	
SEBS ⁴	33:67			100
Paraffinic oil ⁵		400	400	400
Stabilizer ⁶		2.5	2.5	2.5
Breaking strength ⁷ , dyne/cm ²		4 x 10 ⁵	4 x 10 ⁵	4 x 10 ⁶
Tear propagation ⁸ , dyne/cm ²		8 x 10 ⁴	7 x 10 ⁴	1 x 10 ⁶
Compression set ¹⁰ at 24 hours		81% ^R	77% ^R	0.0%
Rigidity, gram	1,536	1,536	1,520	360
Bloom				

1 ¹ Styrene to ethylene and butylene ratio
2 ² Shell Kraton G 1650 having a Brookfield viscosity of 1,500 cps
3 as measured for a 20% weight solids solution in toluene at 25°
4 C.
5 ³ Shell Kraton G 1652 having a Brookfield viscosity of 550 cps as
6 measured for a 20% weight solids solution in toluene at 25° C.
7 ⁴ Shell Kraton G 1651 having a Brookfield viscosity of 2,000 cps
8 as measured for a 20% weight solids solution in toluene at 25°
9 C.
10 ⁵ ARCO prime 200,
11 ⁶ Irganox 1010,
12 ⁷ ASTM D 412 modified,
13 ⁸ ASTM D 1938 modified,
14 ⁹ ASTM D 412 modified,
15 ¹⁰ ASTM D 2395 modified,
16 ^R ruptured completely

17 The results of Table I show the inferior characteristics of low
18 viscosity triblock copolymers having styrene to ethylene and
19 butylene ratios which are below the contemplated range of the
20 preferred composition.

21 EXAMPLE II

22 One hundred parts by weight of a high viscosity
23 poly(styrene-ethylene-butylene-styrene) triblock copolymer (Shell
24 Kraton G 1651) having a styrene end block to ethylene and
25 butylene center block ratio of about 33:67 with 0.1 parts by
26 weight of a stabilizer (Irganox 1010) can be melt blended with
27 various quantities of a naphthenic oil (ARCO Tufflo 6024).
28 Samples having the dimensions of 5 cm x 5 cm x 3 cm were cut and
29 measured for gel rigidity on a modified Bloom gelometer as
30 determined by the gram weight required to depress the gel a
31 distance of 4 mm with a piston having a cross-sectional area of 1

cm². The average gel rigidity values with respect to various oil concentrations are set forth in Table II below.

7570X
3
TABLE II

	Oil per 100 parts of Triblock copolymer	Gel Rigidity, gram Bloom
4		
5		
6	360	500
7	463	348
8	520	280
9	615	240
10	635	220
11	710	172
12	838	135
13	1,587	54

14 EXAMPLE III

15 Example II can be repeated except about 980 parts oil is used
16 and the gel rigidity should be about 101 gram Bloom. Other
17 properties should be: tensile strength at break about 4.4×10^6
18 dyne/cm², elongation at break about 2,4470%, elasticity modulus
19 about 3.5×10^4 dyne/cm², and shear modulus about 3.7×10^4
20 dyne/cm². The tensile strength, elongation, elasticity modulus
21 should be measured with cross-head separation speed of 25
22 cm/minute at room temperature. The shear modulus should be
23 measured with a 1, 2, and 3 kilogram load at room temperature.

24 EXAMPLE IV

25 Example II is repeated except about 520 parts of a polybutene
26 (Amoco Indopol H-300) is used and the gel rigidity should be

1 substantially unchanged with respect to use of naphthenic oil
2 alone.

3 EXAMPLE V

4 Example II is repeated except about 520 parts of a polypropene
5 (Amoco-60) is used and the gel rigidity should be substantially
6 unchanged with respect to use of naphthenic oil alone.

7 EXAMPLE VI

8 Example II is repeated except about 520 parts of a polyterpene
9 (Hercules Piccolyte S10) is used and the gel rigidity should be
10 substantially unchanged with respect to use of naphthenic oil
11 alone.

12 EXAMPLE VII

13 Example II is repeated except about 360 parts of a combined
14 mixture of: 72 parts of a paraffinic oil (ARCO prime 200), 72
15 parts of a naphthenic oil (ARCO Tufflo 6014), 72 parts of a
16 polybutene oligomer (Amoco Indopol H-200), 72 parts of a
17 polypropene oligomer (Amoco Polypropene C-60), and 72 parts of a
18 polyterpene oligomer (Hercules Piccolyte S10) is used and the gel
19 rigidity should be to be substantially unchanged with respect to
20 the use of naphthenic oil alone.

21 EXAMPLE VIII

22 Example III is repeated except 933 parts oil with 147 parts by
23 weight of a high viscosity poly(styrene-ethylene-
24 butylene-styrene) triblock copolymer containing 47 parts of a
25 naphthenic process oil (Shell Kraton G 4609) having a styrene to

1 ethylene and butylene ratio of about 33:67 is used and the
2 physical properties were found to be about substantially
3 unchanged with respect to the components used in Example III.

4 EXAMPLE IX

5 Example III is repeated except 933 parts oil with 147 parts by
6 weight of a high viscosity
7 poly(styrene-ethylene-butylene-styrene)triblock copolymer
8 containing 47 parts of a paraffinic white petroleum oil (Shell
9 Kraton G 4609) having a styrene to ethylene and butylene ratio of
10 about 33:67 is used and the physical properties should be about
11 substantially unchanged with respect to the components used in
12 Example I.

13 EXAMPLE X

14 Example II is repeated except about 400 parts of oil is used
15 and the properties measured were: tear propagation about $1.4 \times$
16 10^6 dyne/cm² , no crack growth in 180° bend under 50 gram load
17 for 5,000 hours at room temperature, tensile strength about $4 \times$
18 10^6 dyne/cm², elongation at break about 1,700%, tensile set about
19 0% at 1,200% elongation, compression set about 0% when tested
20 under 5,000 gram load for 24 hours, and 100% snap back recovery
21 after extension to 1,200%.

22 EXAMPLE XI

23 The procedure of Example II is repeated and a
24 poly(styrene-ethylene-butylene-styrene) triblock copolymer
25 (characterized by a Brookfield Viscosity of a 20 weight percent

1 solids solution in toluene at 25° C. of at least about 1,800
2 cps.) is used having a styrene end block to ethylene and
3 butylene center block ratio of about 32:68 and the gel rigidity
4 should be within the range of about 20 to about 800 gram Bloom.

5 EXAMPLE XII

6 The procedure of Example II is repeated and a
7 poly(styrene-ethylene-butylene-styrene) triblock copolymer
8 (characterized by a Brookfield Viscosity of a 20 weight percent
9 solids solution in toluene at 25° C. of at least about 1,800
10 cps.) is used having a styrene end block to ethylene and butylene
11 center block ratio of about 34:66 and the gel rigidity should be
12 within the range of about 20 to about 800 gram Bloom.

13 EXAMPLE XII

14 The procedure of Example II is repeated and a
15 poly(styrene-ethylene-butylene-styrene) triblock copolymer
16 (characterized by a Brookfield Viscosity of a 20 weight percent
17 solids solution in toluene at 25° C. of at least about 1,800
18 cps.) is used having a styrene end block to ethylene and
19 butylene center block ratio of about 36:64 and the gel rigidity
20 is found to be within the range of about 20 to about 800 gram
21 Bloom.

EXAMPLE XIV

22 The procedure of Example II is repeated and a
23 poly(styrene-ethylene-butylene-styrene) triblock copolymer
24 (characterized by a Brookfield Viscosity of a 20 weight percent
25 solids solution in toluene at 25° C. of at least about 1,800

1 cps.) is used having a styrene end block to ethylene and butylene
2 center block ratio of about 38:62 and the gel rigidity should be
3 within the range of about 20 to about 800 gram Bloom.

4 EXAMPLE XIV-a

5 The procedure of Example II is repeated and a
6 poly(styrene-ethylene-butylene-styrene) triblock copolymer
7 (characterized by a Brookfield Viscosity of a 20 weight percent
8 solids solution in toluene at 25° C. of at least about 1,800
9 cps.) is used having a styrene end block to ethylene and butylene
10 center block ratio of about 31:69 and the gel rigidity should be
11 within the range of about 10 to about 800 gram Bloom.

12 EXAMPLE XIV-b

13 The procedure of Example II is repeated and a
14 poly(styrene-ethylene-butylene-styrene) triblock copolymer
15 (characterized by a Brookfield Viscosity of a 20 weight percent
16 solids solution in toluene at 25° C. of at least about 1,800
17 cps.) is used having a styrene end block to ethylene and
18 butylene center block ratio of about 37:63 and the gel rigidity
19 should be within the range of about 10 to about 800 gram Bloom.

20 EXAMPLE XIV-c

21 The procedure of Example II is repeated and a
22 poly(styrene-ethylene-butylene-styrene) triblock copolymer
23 (characterized by a Brookfield Viscosity of a 20 weight percent
24 solids solution in toluene at 25° C. of at least about 1,800
25 cps.) is used having a styrene end block to ethylene and

1 butylene center block ratio of about 19:81 and the gel rigidity
2 is found to be within the range of about 10 to about 800 gram
3 Bloom.

EXAMPLE XIV-d

4 The procedure of Example II is repeated and a
5 poly(styrene-ethylene-butylene-styrene) triblock copolymer
6 (characterized by a Brookfield Viscosity of a 20 weight percent
7 solids solution in toluene at 25° C. of at least about 1,800
8 cps.) is used having a styrene end block to ethylene and butylene
9 center block ratio of about 20:80 and the gel rigidity should be
10 within the range of about 10 to about 800 gram Bloom.

EXAMPLE XIV-e

12 The procedure of Example II is repeated and a
13 poly(styrene-ethylene-butylene-styrene) triblock copolymer
14 (characterized by a Brookfield Viscosity of a 20 weight percent
15 solids solution in toluene at 25° C. of at least about 1,800
16 cps.) is used having a styrene end block to ethylene and
17 butylene center block ratio of about 38:62 and the gel rigidity
18 should be within the range of about 10 to about 800 gram Bloom.

EXAMPLE XIV-f

20 The procedure of Example II is repeated and a
21 poly(styrene-ethylene-butylene-styrene) triblock copolymer
22 (characterized by a Brookfield Viscosity of a 20 weight percent
23 solids solution in toluene at 25° C. of at least about 1,800
24 cps.) is used having a styrene end block to ethylene and butylene

center block ratio of about 29:71 and the gel rigidity should be within the range of about 10 to about 800 gram Bloom.

EXAMPLE XIV-g

The procedure of Example II is repeated and a poly(styrene-ethylene-butylene-styrene) triblock copolymer (characterized by a Brookfield Viscosity of a 20 weight percent solids solution in toluene at 25° C. of at least about 1,800 cps.) is used having a styrene end block to ethylene and butylene center block ratio of about 26:74 and the gel rigidity should be within the range of about 10 to about 800 gram Bloom.

EXAMPLE XIV-h

The procedure of Example II is repeated and a poly(styrene-ethylene-butylene-styrene) triblock copolymer (characterized by a Brookfield Viscosity of a 20 weight percent solids solution in toluene at 25°C. of at least about 1,800 cps.) is used having a styrene end block to ethylene and butylene center block ratio of about 22:78 and the gel rigidity should be within the range of about 10 to about 800 gram Bloom.

EXAMPLE XIV-i

The procedure of Example II is repeated and a poly(styrene-ethylene-butylene-styrene) triblock copolymer (characterized by a Brookfield Viscosity of a 20 weight percent solids solution in toluene at 25° C. of at least about 1,800 cps.) is used having a styrene end block to ethylene and butylene center block ratio of about 25:75 and the gel rigidity should be

1 within the range of about 10 to about 800 gram Bloom.

2 EXAMPLE XIV-j

3 The procedure of Example II is repeated and a
4 poly(styrene-ethylene-butylene-styrene) triblock copolymer
5 (characterized by a Brookfield Viscosity of a 20 weight percent
6 solids solution in toluene at 25° C. of at least about 1,800
7 cps.) is used having a styrene end block to ethylene and butylene
8 center block ratio of about 26:74 and the gel rigidity should be
9 within the range of about 10 to about 800 gram Bloom.

10 EXAMPLE XV

11 Example II is repeated except about 980 pads oil containing 100
12 parts of a Fe3O4 magnetic particle is used and the gel rigidity
13 should be within the range of about 20 to 800 gram Bloom.

14 EXAMPLE XVI

15 The procedure of Example II is repeated and a
16 poly(styrene-ethylene-butylene-styrene) triblock copolymer
17 (characterized by a Brookfield Viscosity of a 20 weight percent
18 solids solution in toluene at 25° C. of at least about 1,800
19 cps.) is used having a styrene end block to ethylene and butylene
20 center block ratio of about 27:73.

21 EXAMPLE XVII

22 A cushioning element is manufactured that includes a quantity
23 of gel cushioning media formed to have a top, a bottom, and an
24 outer periphery, the cushioning media being compressible so that
25 it will deform under the compressive force of a cushioned object,

1 and a plurality of hollow columns situated in said cushioning
2 media, each of said columns having a longitudinal axis along its
3 length, each of said columns having a column wall which defines a
4 column interior, and each of said columns having a column top and
5 a column bottom. The cushioning element is adapted to have a
6 cushioned object placed in contact with said cushioning element
7 top and the column top and the column bottom of one of said
8 columns are located at two different points on said longitudinal
9 axis of said column. A column's longitudinal axis is located
10 generally parallel to the direction of a compressive force
11 exerted on the cushioning element by a cushioned object in
12 contact with said column top, and at least one of the columns is
13 capable of buckling beneath a protuberance that is located on a
14 cushioned object. The cushioning element is yieldable as a
15 result of compressibility of said cushioning media and
16 bucklability of said column. The cushioning media comprises
17 thermoplastic, heat formable and heat reversible gelatinous
18 elastomer composition, G, which is physically interlocked with a
19 selected material Mn, the gelatinous elastomer composition formed
20 from (a) 100 parts by weight of a high viscosity triblock
21 copolymer of the general configuration
22 poly(styrene-ethylene-butylene-styrene); (b) from about 200 to
23 about 1,600 parts by weight of a plasticizing oil; said
24 composition characterized by a gel rigidity of from about 20 to
25 about 800 gram Bloom; the composition being formed from the

1 combination $G_nM_nG_n$, $M_nG_nM_n$, $M_nG_nG_n$, $G_nG_nM_n$, $M_nG_nG_nM_n$, $G_nM_nG_nG_n$,
2 $G_nM_nM_nG_n$, $G_nM_nM_nG_n$, $G_nG_nM_nM_n$, $G_nG_nM_nG_nM_n$, $G_nM_nG_nG_n$, $G_nG_nM_n$,
3 $G_nM_nG_nM_nM_n$, $M_nG_nM_nG_nM_nG_n$, $G_nG_nM_nM_nG_n$, or $G_nG_nM_nG_nM_nG_n$, wherein
4 when n is a subscript of M , n is selected from the group
5 consisting of foam, plastic, fabric, metal, concrete, wood,
6 glass, ceramics, synthetic resin, synthetic fibers or refractory
7 materials, and wherein when n is a subscript of G , n denotes the
8 same or a different gel rigidity.

9 Although the gel formulations referred to above are most
10 preferred, there are numerous other preferred gels. For example,
11 gels which are made with the same ingredients as those mentioned
12 above, but in different combinations or in conjunction with
13 different ingredients can be used advantageously for this
14 invention. For example, the GLS Corporation of Cary, Illinois
15 offers a gel in injection moldable pellet form under the
16 designation G-6703 which is made with the ingredients of the gels
17 mentioned above but with less plasticizing oil, and has a Shore A
18 hardness of 3. Other preferred gels which may be used in the
19 invention include PVC plastisol gels, silicone gels, and
20 polyurethane gels.

21 PVC plastisol gels are well known in the art, and are
22 exemplified by artificial worms and grubs used in fishing. A
23 description of a typical PVC plastisol gel is given in United
24 States Patent No. 5,330,249 issued in the name of Weber et al. on
25 July 19, 1994, is hereby incorporated by reference. PVC

1 plastisol gels are not the most preferred because their strength
2 is not as high for a given gel rigidity as the gels of the Chen
3 patents, but they are acceptable for use in the invention.

4 Silicone gels are also well known in the art, and are available
5 from many sources including GE Silicones and Dow Corning. From a
6 performance standpoint, silicone gels are excellent gels for this
7 invention. However, the cost of silicone gels is many times
8 higher than the most preferred gels.

9 Polyurethane gels are also well known in the art, and are
10 available from a number of companies including Bayer
11 Aktiengesellschaft in Europe. For reference, the reader is
12 directed to United States Patent No. 5,362,834 issued in the name
13 of Schapel et al. on November 8, 1994, which is hereby
14 incorporated by reference, for more information concerning
15 polyurethane gels. Like silicone gels, polyurethane gels are
16 excellent from a performance standpoint, but are many times more
17 expensive than the most preferred gels.

18 C. Method for Making the Cushions

19 There are several ways in which the cushion can be manufactured
20 from the most preferred gels.

21 1. Injection Molding

22 The invented cushions can be injection molded by standard
23 injection molding techniques. For example, a cavity mold is
24 created with cores inside the cavity. The gel ingredients are
25 heated while stirring, which turns the gel into a liquid. The

1 liquid is injected into the cavity and forms around the cores.
2 The material is allowed to cool, which causes it to solidify.
3 When the mold is parted, the cores pull out of the solidified gel
4 and leave the hollow columns. The cushion is removed from the
5 cavity, the mold is closed, and liquid is injected to form the
6 next cushion, this process being repeated to manufacture the
7 desired quantity of cushioning elements. This results in very
8 inexpensive cushioning elements because the preferred gel is
9 inexpensive and the manufacturing process is quick and requires
10 very little labor.

11 Referring to Figure 4, an example mold in use is depicted. The
12 mold assembly 401 has a first mold half 401 and a second mold
13 half 404. The second mold half 404 has a cavity 408 and a base
14 plate 405 at the bottom of the cavity 408. It also has side
15 walls 414 and 415. The first mold half 402 has a core mounting
16 plate 409 and a plurality of cores 403 mounted on it in any
17 desired spacing and arrangement. The cores 403 may be of any
18 desired shape, such as triangular, square, pentagonal, n-sided
19 (where n is any integer), round, oval or of any other
20 configuration in cross section in order to yield a molded
21 cushioning element 406 of the desired configuration. The cores
22 403 could also be tapered from a more narrow dimension (reference
23 numeral 410) at their end distal from the core mounting plate 409
24 to a wider dimension (reference numeral 411) at their end
25 proximal the core mounting plate. This would create a tapered

1 column or tapered column walls so that the radial measurement of
2 a column orthogonal to its longitudinal axis would be different
3 at two selected different points on the longitudinal axis.
4 Alternatively the cores 403 could be tapered from 410 to 411,
5 stepped from 410 to 411 or configured otherwise to create a
6 column of desired shape. Use of the hexagonal cores 403 depicted
7 yields a cushioning element 406 with cushioning media 412 molded
8 so that the column walls 413 form the hollow columns 407 in a
9 hexagonal configuration.

10 When the first mold half 402 and second mold half 404 are
11 brought together, core distal ends 410 abut the second mold half
12 base plate 405. This prevents liquid cushioning media from
13 flowing between the base plate 405 and the core distal ends 410
14 in order to achieve a cushioning element 406 which has hollow
15 columns through which air can circulate. If the core distal ends
16 410 did not reach all the way to the base plate 408, then the
17 columns 407 would be open at one end and closed at the other.

18 Figure 5 depicts an alternative mold configuration. The mold
19 assembly 501 includes first mold half 502 that includes a first
20 core mounting plate 509 onto which a plurality of cores 503 are
21 mounted in a desired configuration. The cores 503 each have a
22 core proximal end proximal to the core mounting plate 509 and a
23 core distal end 511 distal to the core mounting plate 509. The
24 mold assembly 501 also includes a mold second half 504 which has
25 a core mounting plate 505, side walls 512, and cores 508 each

1 having a core proximal end 513 proximal to the core mounting
2 plate 505 and a core distal end 514 distal to the core mounting
3 plate. The second core half 504 also has a cavity 514 in which
4 its cores 508 are found. The mold assembly 501 may be designed
5 so that when the two mold halves are brought together the core
6 distal ends abut the surface of their opposing core mounting
7 plates. This produces a cushioning element 506 with hollow
8 columns 507 that are open from one end to the other in order to
9 maximize air circulation through the columns 507 and yieldability
10 of the cushioning element 506. Alternatively, the mold assembly
11 501 may be designed so that the core distal ends do not contact
12 the core mounting plates. This will result in a cushion having a
13 cross sectional appearance like that depicted in Figure 6, where
14 the columns are shorter in length than the thickness of the
15 cushioning element, so the columns are closed at one end.

16 2. Extrusion

17 The invented cushioning elements may also be manufactured by
18 typical extrusion processes. If extrusion is used, hot liquid
19 gel is forced through an extrusion die. The die has metal rods
20 situated to obstruct the path of the gel in some locations so
21 that the gel is forced through the die in a pattern resembling
22 the desired shape of the finished cushioning element. Thus the
23 die, having an aperture, an aperture periphery, and forming rods
24 within the aperture has an appearance similar to that of the
25 desired cushioning element except that the portions of the die

1 that are solid will be represented by empty air in the finished
2 cushion, and the portions of the die in the aperture that are
3 unobstructed will represent gel in the finished cushioning
4 element. Thus the rods of the die should be of the shape and
5 size that the desired cushioning element is intended to be; the
6 spacing of the rods should approximate the spacing of the columns
7 that is desired in the finished cushioning element; and the shape
8 and size of the aperture periphery should approximate the shape
9 and size of the periphery of the desired cushioning element.

10 When gel is forced through the die, the liquid gel is cooled
11 during its traverse through the die, causing it to solidify as it
12 leaves the die. The gel is cut at desired length intervals
13 to form cushioning elements. Of course, cushioning elements so
14 formed have hollow columns throughout their length, although the
15 columns could be sealed as mentioned elsewhere herein. It not
16 expected, however, that extrusion is a practical method for
17 manufacturing cushions with columns that vary in dimension along
18 their length. The extruded cushioning element is very
19 inexpensive because the both the cushioning media (i.e. the
20 preferred gel) is inexpensive and the manufacturing process is
21 highly automated so that labor requirements are very low.

22 3. Casting

23 Another manufacturing process by which the invented cushioning
24 element can be made is by generally known casting technology. In
25 order to cast the invented cushioning element, hot liquid gel (or

1 other cushioning media) is poured into an open cavity, and an
2 assembly of metal rods is pushed into the liquid. The rods will
3 form the columns of the finished product. The liquid flows
4 between the metal rods, cools and solidifies. The metal rods are
5 then removed, leaving the hollow portions of the columns, and the
6 cushion is removed from the cavity. A vibrator may be used to
7 vibrate the cavity to facilitate the flow of the liquid between
8 the rods if needed.

9 Casting is a more labor intensive manufacturing method than
10 injection molding or extrusion, but the tooling is generally less
11 expensive, especially for large cushions. This is the preferred
12 method of making very large cushions, such as king-size bed
13 mattresses, since the size of such cushions is greater than that
14 which can be manufactured using injection molding or extrusion
15 methods.

16 The reader should note that any other manufacturing method may
17 be used which results in the a cushioning element having the
18 general configuration of or achieving the object of this
19 invention. Such other methods may include but are not limited to
20 rotational molding of a cushioning media such as a hot liquid
21 gel, and vacuum forming of sheets of a cushioning media such as
22 gel.

23 While the present invention has been described and illustrated
24 in conjunction with a number of specific embodiments, those
25 skilled in the art will appreciate that variations and

1 modifications may be made without departing from the principles
2 of the invention as herein illustrated, described, and claimed.

3 The present invention may be embodied in other specific forms
4 without departing from its spirit or essential characteristics.
5 The described embodiments are to be considered in all respects as
6 only illustrative, and not restrictive. The scope of the
7 invention is, therefore, indicated by the appended claims, rather
8 than by the foregoing description. All changes which come within
9 the meaning and range of equivalency of the claims are to be
10 embraced within their scope.